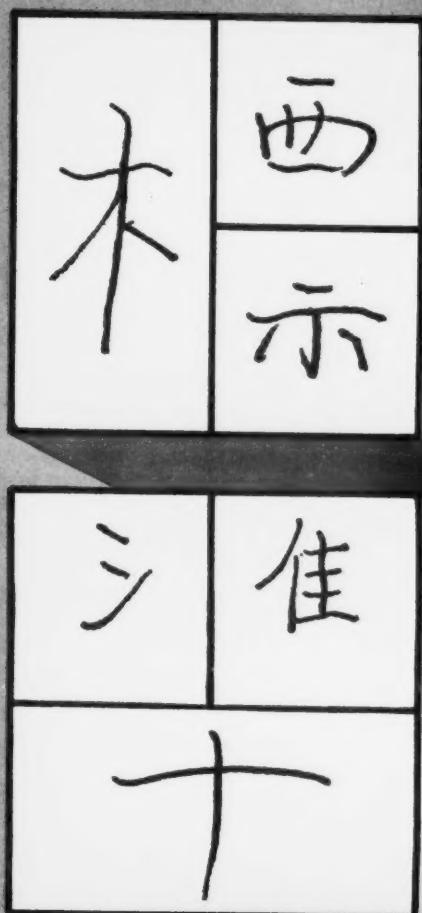


NATIONAL BUREAU OF STANDARDS

July/1968

# Technical News Bulletin



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科學新聞簡報

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TECHNOLOGY & SCIENCE

U.S. DEPARTMENT OF COMMERCE

# NATIONAL BUREAU OF STANDARDS

# T N B

Technical  
News  
Bulletin

JULY 1968/VOL. 52, NO. 7/ISSUED MONTHLY



U.S. DEPARTMENT OF COMMERCE

C. R. Smith, Secretary

NATIONAL BUREAU OF STANDARDS

A. V. Astin, Director

## CONTENTS

- 143 Linqistic Analysis at NBS
- 145 Center for Radiation Research Created
- 146 Dielectric Constant and Polarizability Determined for Solid Parahydrogen
- 147 Wright Named Chief of Building Research
- 148 Artificial Weathering Devices
- 150 Pressure Transducer Evaluation Studied
- 153 Clearinghouse
  - Improved Request Processing System
  - New Ordering Procedures for DDC Users
  - CAST
- 154 NBS Studies Atmospheric Corrosion Fatigue
- 156 Conference and Publication Briefs
  - Ceramics Symposium Held at NBS
  - Electronic Composition in Printing
  - Organic Coatings
  - Weatherability of Plastics
  - Scheduled NBS-Sponsored Conferences
- 158 Standards and Calibration
  - Calibration Service for Microwave Power in WR28 Waveguide (26.5-40.0 GHz)
  - Calibration Services for Reflectors and Nonreflecting Ports in WR42 Waveguide (18.0-26.5 GHz)
  - NBS Increases Photodetector Calibration Service
  - New Edition of "NBS Calibration and Test Services"
  - New USA Standard Nomenclature and Symbols for Radiation, Light, and Color
  - Tennessee Receives New Weights and Measures Standards
  - Standard Frequency and Time Broadcasts
- 161 Standard Reference Materials
  - Zinc Chemical Composition Standards
  - Cast Steel Standards
  - Radioactivity Standards
  - Cadmium-109—Silver-109m Standard
  - Radium-226 Solution Standards
- 162 NSRDS News
  - NSRDS Coverage of Atomic and Molecular Properties
  - Thermodynamic Properties of Copper, Silver, and Gold
  - Second Conference on Neutron Cross Sections and Technology
  - Proceedings of the Forum of Federally Supported Information Analysis Centers
  - Second Edition of OMNITAB Published
- 165 Patents Granted on NBS Inventions
- 167 Publications of the National Bureau of Standards

**COVER:** *The Chinese characters (right) translate to "U.S. Department of Commerce, National Bureau of Standards, Technical News Bulletin." The two enlarged characters, which mean "standards," illustrate the analytical methods developed at NBS to describe the formation processes of Chinese characters. (See page 143.)*

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

- The Institute for Basic Standards
  - The Institute for Materials Research
  - The Institute for Applied Technology
  - Center for Radiation Research
- The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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# linguistic analysis AT NBS

## Scheme Developed for Synthesizing Chinese Characters

■ It is fortunate that most of the world's written languages are linear; the fact that their words can be arranged in lines of characters enables their users to easily type a letter or encode words in a computer language. Communicating by means of word symbols can be much more difficult, however, as in the case of the Chinese written language. Typesetting a Chinese newspaper, for example, requires the use of thousands of characters, the two-dimensional characteristics of which present still greater problems in encoding Chinese text for computer storage and processing.

For six years the Center for Computer Sciences and Technology of the NBS Institute for Applied Technology has conducted a continuing study of ways of representing two-dimensional information in general and Chinese characters in particular. A scheme developed by B. Kirk Rankin III, Stephanie Siegel, Ann Swanson, and James L. Tan now describes how Chinese characters are formed.<sup>1</sup> The scheme is in effect a "grammar" for placing in all allowable combinations the components given in an accompanying lexicon. This work, a possible application of which might be the eventual direct machine reading of Chinese text, was conducted with support from the Army Signal Corps and the Air Force.

### Data Encodability

The memory of a digital computer stores serial information—analogue

to the letters of this sentence—by expressing each element of the series in the computer's digital format. Two-dimensional information must somehow be converted into serial form before it can be digitized and put into the memory; this applies to roadmaps, drawings, and chemical configurations, as well as to Chinese characters. In the past, scientists of the Center have experimented with reading such information into digital computers by a variety of means. One of these is a scanning system producing a chain of

digital data.<sup>2</sup> In the case of MAGIC, the Center's Machine for Automatic Graphics Interface to a Computer, each point is identified by its rectangular coordinates.<sup>3</sup> Linear notation for all anticipated two-dimensional configurations has been used to store chemical information.<sup>4</sup>

### Natural Language Grammars

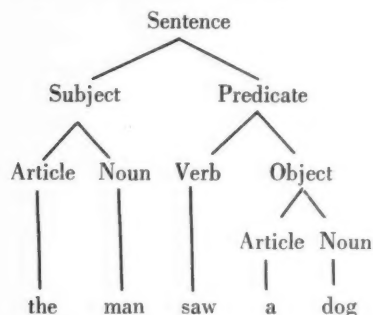
The NBS approach to representing Chinese characters has resulted in a number of formal grammars, devices which define languages. Formal gram-

*continued*  
143



*By interchanging components within a basic frame, Kirk Rankin and Ann Swanson create different Chinese characters.*

grams are normally used in the study of the sentence structure of natural languages, such as English. A grammar for English sentences, for example, would account for the fact that the sequence of words, "The man saw a dog," is a grammatical sentence, but that the reflection of that sentence, "dog a saw man the," is not a grammatical sentence. It would do so by generating the first sentence and associating with it a tree structure which might look like the following:



The "picture syntax" concept developed in the late 1950's by R. A. Kirsch, of the Bureau's Applied Mathematics Division, suggested that two-dimensional data could be treated by formal grammars in much the same way as one-dimensional information. Subsequently a study of the structure of Chinese characters in terms of component combinations showed that to form the characters we must deal with at least three kinds of combination possibilities: vertical combinations (components one above the other), horizontal combinations, and surrounding-enclosed combinations. All three relationships can be found together in some characters.

### Frame Embedding

The picture syntax concept showed that most Chinese characters are written as if in parts of a frame that can be divided in half, and its smaller subframes successively rehaved. The simplest character occupies a frame by itself:



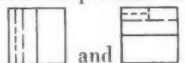
The first division can be either horizontal, vertical, or surrounding:



The next division can be embedded in one of the subframes already obtained in horizontal or vertical division, including the following:



Two further divisions are allowable, producing four or five subframes, to attain such complexities as:



### Component Lexicon

Many of the characters which can occupy a whole frame alone are also used in embedded frames as components. Each of these and the other components which are used only in combinations tend to be found only in certain positions and to play certain parts in forming characters with a group of co-constituents. These positions, in addition to FREE (can be sole constituent, occupying an undivided frame), were described as WEST, EAST, NORTH, SOUTH, BORDER, and INTERIOR.

These patterns of usage enabled the researchers to form a lexicon, or dictionary of components, giving for each entry the positions it can occupy in forming characters. Some components are checked as occurring as F (FREE), in W, E, N, S, as I (INTERIOR), and B (BORDER); most, however, are allowable for only some of these positions and some for only one position.

Also given by the lexicon for each component is its "strength," the extent to which it occurs with other components and complex subcharacters. This is indicated for each position (W, E, N, and S) by an "s" (strong) or "8" (not strong) tally in that column. All components in BORDER usage

are automatically strong, since a border must have an interior. All INTERIORS, on the other hand, are not-strong, because of their weak pattern of co-occurrence, and FREEs are, by definition, not-strong.

A factor opposite to FREE is "adjunctiveness," typifying components which cannot occur as FREE and which are strong in the W, E, N, S, and B positions. These components are always in construction with other collateral components. Adjunctive components are identified in the lexicon by the absence of a tally for FREE and are used where a strong-and-not-free component is called for.

### Repetitive Components

Some components are found in some characters to be repeated in patterns which can themselves be treated as components. This is indicated by the lexicon in columns headed V (repeated vertically), C (horizontal continuous), T (triangular), and D (horizontally discontinuous). Components that can be used as V, C, and T are also not-strong in WEST, EAST, NORTH, SOUTH, INTERIOR, and FREE. Components that can be used as D are also strong adjuncts in BORDER and have no other uses.

### Application to Field of Chemistry

Currently, a similar approach is being undertaken in the analysis of chemical graphs by the same group under the sponsorship of NIH. It is hoped that a linguistic study of the structure of chemical graphs will result in a solution to the problem of automatically displaying chemical graphs.

<sup>1</sup> B. K. Rankin III, S. Siegel, A. McClelland, and J. L. Tan, *A Grammar for Component Combination in Chinese Characters*, NBS Tech. Note 296 (Nov. 1966) available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 35 cents.

<sup>2</sup> Digital computer used for quantitative metallographic analyses, NBS Tech. News Bull. 47, 26-28 (Feb. 1963).

<sup>3</sup> MAGIC computer system reads diagrams drawn on screen, NBS Tech. News Bull. 50, 134-136 (Aug. 1966) and Exploratory research in information processing at NBS, NBS Tech. News Bull. 51, 182-184 (Aug. 1967).

<sup>4</sup> New chemical notation system, NBS Tech. News Bull. 49, 128 (Aug. 1965).





## CENTER FOR RADIATION RESEARCH CREATED

■ A Center for Radiation Research (CRR) has recently been formed at the Bureau. The creation of the Center consolidates the Bureau's extensive radiation facilities which had been split between the Radiation Physics Division of the NBS Institute for Basic Standards and the Reactor Radiations Division of the NBS Institute for Materials Research.

C. O. Muehlhause, formerly chief of the Reactor Radiations Division, has been named to direct the Center for Radiation Research, with R. S. Caswell as his deputy. The Center is organized into four divisions. They are headed by R. S. Carter, Reactor Radiation; J. E. Leiss, Linac Radiation; H. H. Landon, Nuclear Radiation; and J. W. Motz, Applied Radiation.

Special radiation facilities at the National Bureau of Standards include a ten megawatt nuclear research reactor and a 100 million electron volt linear electron accelerator, as well as a number of other radiation-producing machines and sources. The facilities are available to other Government agencies, industrial laboratories, and to the science-oriented academic community of Washington (D.C.) and beyond.

### Reactor

The NBS Reactor (NBSR), although not yet operating at full power, recently achieved criticality.<sup>1</sup> When in full operation the NBSR will provide intense thermal neutron beams which will constitute a powerful tool in the analysis of the structure of solids and liquids by neutron diffraction and scattering. Neutron diffraction is used to investigate various structural properties, such as the location of hydrogen atoms and the distribution of magnetism in crystals, whereas neutron inelastic scattering is used to investigate intermolecular forces and chemical bond strengths.

Another important use of the neutron beams from the NBSR will be in the study and measurement of such nuclear processes as fission and neutron capture. The high flux from the reactor will also be used to generate radioisotopes for a wide variety of purposes, such as activation analysis and tracer production.

In addition, studies of the effects of radiation on materials will be carried out with the NBSR by in-pile irradiation of bulk matter. The information obtained in this way should be of great value, both for basic knowledge in solid-state and chemical physics and for application to radiation processing and methods of altering the properties of structural materials.

### Linac

The linear accelerator (linac) provides NBS with high-intensity electron and gamma radiation with which to establish new standards and measuring techniques, and

to enter new areas of basic research in nuclear physics. This research consists primarily in probing the structure of nuclei with high energy electrons; ejecting various particles from the nucleus by gamma ray bombardment; and in producing fast neutrons with which to make neutron cross section measurements, i.e., to determine the probability of neutrons interacting with nuclei.

Precision control of the facility in these activities enables NBS to greatly extend its measurement and standards capability in respect to high intensity beam monitoring, radiation field measurement, and high energy-high intensity dose determinations. These activities are vital to the ever-growing industrial uses of radiation in such areas as the sterilization of pharmaceuticals, the preservation of foods, the polymerization of plastics, and radiation processing generally.

In addition to these large plant type facilities—the reactor and linac—the Center has two Van de Graaff machines, a dynamitron, several x-ray generators, and an isotope separator. The latter consists of a machine-laboratory complex housed in its own building annex.

### Facility Sharing

The radiation facilities described above and their operating staffs, together with the Center's health physics and theoretical groups, comprise the resources of the Center. Management of these extensive resources makes the responsibilities of the Center somewhat different from those of the Bureau's three institutes. Like the institutes, the CRR has a prime responsibility for carrying out the Bureau's mission in an extensive but well-defined field of science and technology—in this case nuclear radiation. But in addition the CRR places equal emphasis on the application of its resources and capabilities to the solution of problems arising outside its own organization—in other Government agencies, in the universities, and in industry, as well as in the other parts of the Bureau. This approach should be of particular value in the utilization of such large multipurpose facilities as the reactor and the linac. In both these facilities a hard core of operating, maintenance, and user staff provides a continuity of plant, equipment, and basic programs that can be of great benefit to outside collaborators.

The emphasis on collaboration, cooperation, and facility sharing is natural in the management of a large multipurpose facility. It is also in keeping with the Administration's policy of making wider use of the Government's unique technical resources. Through the CRR program the Bureau hopes to further the development of collaborative use of facilities by a broader segment of the scientific community.

<sup>1</sup> NBS reactor achieves criticality, NBS Tech. News Bull. 52, No. 3, 50 (Mar. 1968).

*B. A. Younglove balances the capacitance bridge used to measure the dielectric constant of solid parahydrogen.*



## DIELECTRIC CONSTANT AND POLARIZABILITY DETERMINED FOR SOLID PARAHYDROGEN

■ Recent NBS research on the physical properties of materials at low temperatures has resulted in the first accurate determination of the dielectric constants of solid parahydrogen.<sup>1</sup> The dielectric-constant values were then used, together with hydrogen density values available in the literature, to calculate accurate values for the polarizabilities (more properly termed the Clausius-Mossotti function) of solid parahydrogen. All measurements of solid parahydrogen were made on the melting line, or phase boundary of the liquid and solid hydrogen, at pressures between 18 and 320 atmospheres and temperatures between 14.4 and 22.2 K. The investigation was carried out by B. A. Younglove, Cryogenics Division, NBS Institute for Materials Research, under the sponsorship of the National Aeronautics and Space Administration.

These research results are important, not only to basic science, but also to the U.S. space program, since dielectric-constant measurements on solid hydrogen are needed for density metering of fuel tanks containing hydrogen slush—a liquid-solid mixture now under development as a potential space fuel.

In the past, considerable research, mainly theoretical, has been done on the polarizability and the dielectric constant of hydrogen. Hydrogen has been of particular interest to researchers because it has large variations in isotopic mass and exists in ortho and para modifications, all

of which affect polarizability. Most of the experimental research, however, has been carried out on low-density hydrogen gas and liquid hydrogen. Very little investigation has dealt with solid hydrogen, because voids tend to occur in cryogenic solids, making it difficult to obtain a uniform sample for experimental purposes. During the NBS study, a procedure for obtaining a reproducible solid sample was devised making possible the accurate measurements of the dielectric constants and, thus, the calculation of polarizabilities of solid parahydrogen.

The dielectric constant was measured as the ratio of the capacitance of the condenser with sample to the capacitance in vacuum. Capacitance was measured with a commercial three-terminal capacitance bridge, using tapped transformer windings in the ratio arms.

The condenser was made from two coaxial right-circular cylinders of copper. The outer cylinder was operated at 10 volts and 5 kHz; the inner cylinder was connected to the detector side of the bridge, which at balance was at ground potential. The capacitor had a value in vacuum of approximately 24 pF and a conductance of less than  $10^{-8}$   $\mu$ mho. Under these conditions, the bridge could be balanced, even with sample present, with a sensitivity of about  $\pm 0.002$  pF.

Polarizabilities, or the Clausius-Mossotti function, were obtained by combining the dielectric constant measurements with accurate density measurements available in the

literature. The Clausius-Mossotti function, along with corresponding values of temperatures, pressures, densities, and dielectric constants, were then compiled in tables. The precision in polarizability of a few parts in 10 000 indicates a quite reproducible state of the solid sample.

Although simple theory states that the Clausius-Mossotti function is a constant for a nonpolar substance such as hydrogen, it was not clear, until the NBS research on solid parahydrogen was conducted, whether there would be a change in the Clausius-Mossotti function for hydrogen on freezing. The results of the NBS study show an increase of about 0.3 percent in polarizability of the solid over the liquid at the same density. Also, the polarizability of solid parahydrogen was found to be quite insensitive to temperature or density changes.

<sup>1</sup> For further details, see *Accurate measurements made of the dielectric constant and polarizabilities of solid parahydrogen*, by B. A. Younglove, J. Chem. Phys. (to be published).

*NBS values of polarizability and dielectric constants of solid parahydrogen as a function of density, temperature, and pressure were obtained on the melting line or phase boundary of liquid and solid hydrogen.*

$\rho$ (g/cm <sup>3</sup> )	$\rho$ (cm <sup>3</sup> /g)	$\epsilon$	T (K)	P (atm)
0.08694	1.0066	1.28770	14.4	17.91
0.08718	1.0062	1.28846	14.6	24.19
0.08742	1.0062	1.28959	14.8	30.55
0.08742	1.0062	1.28932	14.8	30.55
0.08767	1.0068	1.29044	15.0	36.99
0.08767	1.0064	1.29029	15.0	36.99
0.08841	1.0066	1.29306	15.6	56.80
0.08891	1.0068	1.29493	16.0	70.41
0.08916	1.0065	1.29577	16.2	77.34
0.08941	1.0066	1.29669	16.4	84.35
0.08966	1.0066	1.29762	16.6	91.43
0.08966	1.0066	1.29760	16.6	91.43
0.08991	1.0063	1.29843	16.8	98.60
0.08991	1.0064	1.29845	16.8	98.60
0.08991	1.0068	1.29858	16.8	98.60
0.09016	1.0062	1.29930	17.0	105.85
0.09038	1.0067	1.30028	17.2	113.02
0.09063	1.0067	1.30118	17.4	120.45
0.09088	1.0068	1.30214	17.6	127.96
0.09138	1.0071	1.30408	18.0	143.21
0.09188	1.0063	1.30564	18.4	158.79
0.09238	1.0065	1.30754	18.8	174.67
0.09262	1.0065	1.30843	19.0	182.72
0.09287	1.0066	1.30936	19.2	190.85
0.09312	1.0062	1.31036	19.4	190.05
0.09337	1.0064	1.31114	19.6	207.32
0.09361	1.0069	1.31221	19.8	215.67
0.09361	1.0067	1.31211	19.8	215.67
0.09410	1.0066	1.31388	20.2	224.10
0.09435	1.0067	1.31484	20.4	241.16
0.09555	1.0062	1.31908	21.4	285.06
0.09579	1.0063	1.32004	21.6	294.05
0.09603	1.0062	1.32090	21.8	303.10
0.09626	1.0062	1.32172	22.0	312.23
0.09650	1.0063	1.32266	22.2	321.43

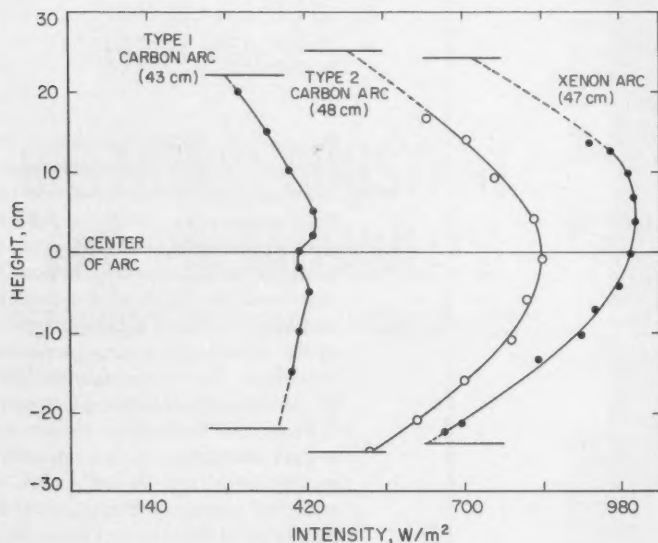
## WRIGHT NAMED CHIEF OF BUILDING RESEARCH

■ James R. Wright has been named Chief of the NBS Building Research Division. Dr. Wright has been with the Bureau since 1960; he held the positions of Assistant Chief of the Materials and Composites Section, Assistant to the Chief of the Building Research Division, and Acting Chief of the Division before his present appointment. For nine months in 1964-65, he was a Department of Commerce Science and Technology Fellow with a work assignment as a management analyst with the Patent Office. In 1967, he completed the program for management development at the Harvard Business School.

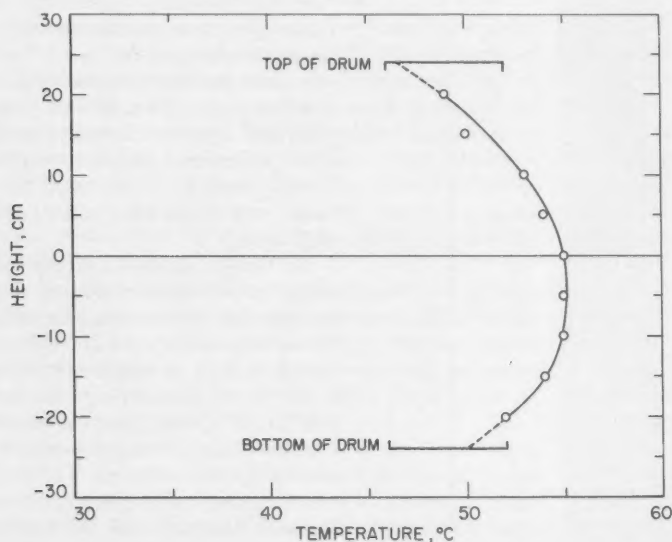
As Chief of the NBS Building Research Division, Dr. Wright will be in charge of a research activity which defines performance requirements of building materials, elements, and whole structures; and develops measurement techniques for use by those who write performance specifications, standards, and codes. The Division's principal areas of investigation include structures, interior environments, durability, unwanted fires, codes and standards, and systems engineering.

Dr. Wright received a B.S. in Education from Salisbury State College in 1946 and a B.S. in Chemistry from Washington College in 1948; he received an M.S. in organic chemistry in 1949, and his Ph.D. in the same field in 1951, both from the University of Delaware. Prior to joining the Bureau he was with the California Research Corporation, the Southwest Research Institute, and Trinity University.

# ARTIFICIAL WEATHERING DEVICES



Above: The variation of irradiance as a factor of height on the sample drum was monitored for three artificial weathering devices. Below: The black-panel temperature on the sample drum, like irradiance, varied with height.



## Radiation Characteristics Studied

■ Three widely used types of artificial weathering machines were recently studied at the NBS Institute for Applied Technology.<sup>1</sup> J. E. Clark and C. W. Harrison, NBS Research Associates sponsored by the Manufacturing Chemists' Association, conducted the study to determine the radiation characteristics of the devices. Such characterization should make possible better simulation of solar radiation, which is considered to be one of the most important factors in the deterioration of polymers.

Degradation of polymers exposed to weather is caused primarily by solar radiation (ultraviolet, visible, infrared), temperature, water (dew, rain, humidity, snow), and other atmospheric constituents (such as oxygen, ozone, oxides of sulfur). Duplicating these environmental causes of degradation should allow the effects of weathering to be reproduced in the laboratory. However, there is a lack of general correlation of results between exposure of materials to natural and to artificial weathering. A major cause for this lack is the scarcity of significant data defining both the natural and artificial exposure conditions. The purpose of this work, therefore, was to obtain data on three important types of artificial



weathering devices to permit better correlation of exposure results.

### Equipment

Artificial weathering machines provide a central radiant energy source that produces radiant flux closely matching the surface intensity of solar radiation—about  $740 \text{ W/m}^2$ . Surrounding the radiant energy source is a cylindrical specimen rack, or sample drum. In addition to the radiant energy source, these devices permit the control of other weather factors such as temperature, moisture, and atmospheric constituents. The three machines investigated in this work were a xenon-arc device and two different types of carbon-arc devices.

The xenon-arc device used in this study has a 6 kilowatt high-pressure, water-cooled lamp with pyrex jackets. The first carbon-arc device uses three cored carbons, one as the upper electrode and two as the bottom, all of which are enclosed in a bell-shaped pyrex globe. The second carbon-arc device uses three pairs of carbon electrodes, burning one pair at a time and automatically shifting from one pair to another as the carbons are consumed.

A fourth radiant energy source whose irradiance was measured as a check on the monitoring equipment was the NBS standard-type 1000-watt coiled-coil, tungsten-filament quartz-iodine lamp. A radiometer was used to monitor total radiation intensity received.

### Results

The curves for irradiance at the sample drum normal to the center of the arc were plotted for typical 1-hr periods for the three artificial weathering devices studied. The flat curve of irradiance from the xenon arc for this period contrasts sharply with the irregular curves obtained for both carbon arcs.

The xenon-arc device showed a relatively constant irradiance at the sample drum of  $910 \text{ W/m}^2$  over a 1-hr period. Average, maximum, and minimum irradiances from the first car-

bon-arc device at the sample drum were 440, 679, and  $279 \text{ W/m}^2$ , respectively. Average, maximum, and minimum irradiances from the second carbon-arc device at the sample drum were 667, 1020, and  $315 \text{ W/m}^2$ , respectively.

The change in irradiance with sample height in the drum for the carbon and xenon arcs, in the plane of the sample drum parallel to the arc, was determined by moving the sensor. All three devices had a maximum irradiance near the center of the drum; intensities at the top and bottom of the drum were 15 to 40 percent less.

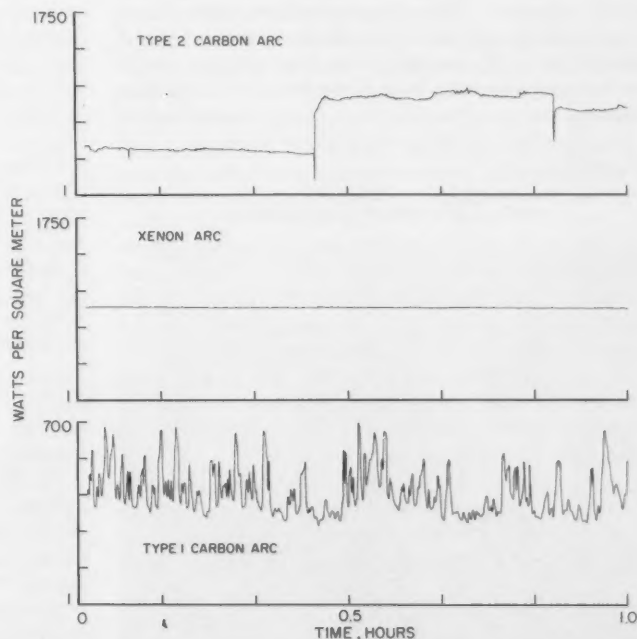
The maximum irradiance for the xenon arc was about 2.1 times that of the first carbon arc. This intensity factor can be important in the acceleration of degradation of polymeric materials.

To determine the distribution of temperature inside the xenon arc device, standard black-panel temperature measurements were made at various drum heights. Temperatures of a similar white panel were also measured.

The plot of height versus black-panel temperature resulted in a parabolic curve. Like irradiation, temperature diminished at the top and bottom of the drum. Black-panel temperatures in the drum plane varied no more than  $\pm 4 \text{ deg C}$  from the average in this xenon arc device. The white panel gave similar results. Black- and white-panel temperatures measured at the center of the xenon arc sample drum were 53 and  $43^\circ \text{C}$ , respectively.

<sup>1</sup> For further technical details, see *Accelerated weathering of polymers: Radiation*, by J. E. Clark and C. W. Harrison, J. Appl. Poly. Sci., Applied Polymer Symposia, No. 4, 97-110 (1967).

Typical irradiance at the sample drum for one hour was measured for three types of artificial weathering devices.



# PRESSURE TRANSDUCER EVALUATION STUDIED

■ Transducers, devices that change energy from one form to another, are extensively used in today's technology for the sensing of physical quantities. Research and development in such fields as aeronautics, astronautics, and oceanography, as well as control in many process industries, rely heavily on measurements made by transducers that produce electrical output. Some electromechanical transducers, moreover, are gradually becoming accepted as working standards in these and other fields.

Recognizing the increasingly important role of electromechanical transducers in the measurement of quantities like pressure, acceleration, and vibration, the National Bureau of Standards has been engaged in a continuing program of research into improved methods for the calibration and evaluation of these devices. Agencies of the Department of Defense and the National Aeronautics and Space Administration have supported these efforts, which, among other achievements, have resulted in the development of several techniques for determining the performance characteristics of pressure transducers.<sup>1</sup>

The Bureau has devoted a major part of its transducer program to pressure transducers because they are used more extensively in the fields of interest than is any other kind of transducer. The program includes determining performance characteristics at a variety of environmental conditions in which sensors of this type are required to make measurements with desired precision and reliability. Knowledge of these performance characteristics assists the user in selecting the best transducer for a particular application.

## Types of Pressure Transducers

An electromechanical pressure sensor consists, generally, of a force-summing member, such as a diaphragm, bellows, or Bourdon tube, that distorts in response to the pressure, thereby converting the pressure signal to a displacement signal. The displacement output of the pressure sensitive element is further converted into an electrical signal by one of a variety of mechanisms that utilize change of electrical resistance, inductance, or capacitance or that generate a voltage.

Most of the pressure transducer work at the Bureau has been concerned with diaphragm-type transducers in which the resistance principle is used to convert displacement of the diaphragm to an electrical signal. Such transducers require electrical excitation to convert the resistance change into an electric current that can actuate an indicating or recording device.

Strain gages or potentiometers are commonly used as the resistance elements in these transducers. The strain



Paul Lederer triggers his "poor man's shock tube" to apply a pressure step to the transducer mounted on the disk. This device uses easily available components—a solenoid-operated valve, an accumulator tank pressurized from the laboratory air line, and simple electrical circuitry.

gage may be bonded or unbonded. In the unbonded strain gage, a taut wire element, the resistance of which changes in response to change in tension, is anchored to the diaphragm at several points. In the bonded strain gage, the resistance wire, foil, or semiconductor material is bonded to the diaphragm. The strain gages may also be attached to an auxiliary member, such as a beam or tube actuated at the force-summing diaphragm. In one type of semiconductor strain gage having a silicon diaphragm, the strain gage is formed by diffusion of dopants directly into the silicon. Strain gage elements are usually connected in a bridge circuit arrangement to compensate for temperature effects.

In the potentiometer type pressure transducer, the diaphragm is connected to a variable resistor by a motion-magnifying linkage. The variable resistor is designed to respond smoothly to the input motion in order that the resistance change will accurately reflect the motion of the diaphragm.

## Sensor Performance Characteristics

Among the important performance characteristics of transducers (for precise definitions of these characteristics, see the reference given as footnote 1) are the following:

The *range* of pressures over which the transducer is intended to measure.

The *full-scale output* of the transducer, i.e., the difference between the maximum and minimum output values.

The *sensitivity* which refers to the response per unit input, for example, millivolts per pound per square inch. The sensitivity may not be the same over the instrument's range.

The transducer output voltage at zero pressure.

*Linearity* of the relationship between electrical output and pressure input.

*Hysteresis* or failure of the transducer to show the same values at the same pressure for ascending and descending pressures.

The smallest increment of pressure which produces an observable change in the transducer output, usually referred to as *resolution*.

Stability of the transducer characteristics over a specified period of time or *repeatability*.

The amplitude and phase responses of a transducer are acceptable only over a frequency range which includes no instrument resonances; this applies to all waveforms, which may be considered as synthesized from harmonics of a sine wave. Thus, faithful reproduction can be expected only for those transients containing frequencies below the lowest *resonance* of the transducer. The frequency of this resonance is therefore used as an indicator of the upper limit of the frequency range for the measurement of dynamic pressures.

*Rise time* is essentially the speed with which a transducer responds to an input step. It also represents an upper limit to its frequency response.

Additional performance characteristics obtained during the testing program include thermal sensitivity shift, thermal zero shift, steady-state acceleration effects, vibration acceleration effects, thermal gradient effects, consequences of power supply variations, warmup effects, mounting torque effects, cycling effects, and storage effects. All resistive pressure transducers can be examined for these characteristics; potentiometric transducers are tested also for contact resistance and dry friction damping.

### Basic Transducer Test Equipment

Many of the pressure transducers tested at the Bureau receive a static calibration in a procedure using dead-weight piston gage systems as sources of known pressures between 0.3 psi and 500 psi. Dry air or nitrogen is the pressure transfer medium in most cases; it is admitted under sufficient pressure to "float" the piston as it is rotated to eliminate frictional errors. Pressure transducers with higher ranges are calibrated with an oil-filled piston gage system.

Transducers requiring external excitation receive it from a low-drift commercial constant-voltage semiconductor supply. Semiconductor strain gages may also be tested with a highly stable constant-current supply.

The outputs of transducers being calibrated are measured with a laboratory potentiometer. In the case of the potentiometric transducers, the transducer and a precision decade voltage divider are energized in parallel. A galvanometer connected between the divider output and the transducer sliding contact enables the transducer resistance ratio to be determined as a function of the applied pressure.

### Static Calibration of Pressure Transducers

Transducers are calibrated statically by making either 11 or 21 output measurements, corresponding to intervals of 20 percent or 10 percent of the pressure range. The transducer output is measured twice at each pressure (except the highest one), once following a pressure increase and again following a pressure decrease. Precautions taken include warming up the equipment for at least 45 minutes before use and seating the transducer with the torque recommended by the manufacturer.

The calibration cycle ends at its origin point, and permits assessment of such characteristics as linearity, hysteresis, and repeatability. These, as well as sensitivity, are obtained by processing the calibration data in a simple computer program. Usually, several calibration cycles are run consecutively to evaluate reproducibility of the data.

### Dynamic Performance Characteristics

Since almost all transducers are expected to sense time-varying quantities, knowledge of their dynamic performance characteristics is needed. These characteristics can be given in terms of response curves which can be calculated from analysis of transducer response to a transient pressure stimulus of known mathematical description.<sup>2</sup> The most convenient transient waveshape for this purpose is a step-function.

Several pressure-step generating devices are available. In one a simple, quick-opening valve mechanism produces gas pressure steps up to about 100 psi in less than 2 ms.<sup>3</sup> A more sophisticated device, the shock tube, generates gas pressure steps of amplitudes from 6 psi to about 1000 psi and rise times of less than a microsecond.

*continued*

*Randolph Williams watches the oscilloscope presentation of the output of a strain gage pressure transducer being vibrated on a shaker (center). Some transducers are little affected by vibration while others may completely lose their signals.*



## PRESSURE TRANSDUCER *continued*

If the rate of rise of the pressure step is sufficiently high, the mechanical and acoustical resonances of the transducer will be excited and the transducer will "ring." This transducer response is recorded on a magnetic drum and subsequently analyzed to determine the transducer's resonances, and particularly the lowest resonance. As previously indicated, a transducer should be used to reproduce pressure transients containing only frequencies below the lowest resonance found from the analysis.

Quick-opening valve devices also may be used to investigate transient-initiated characteristics of longer duration. A liquid-medium step-function calibrator<sup>4</sup> has been used for such investigations.

### Environmental Tests

As pressure transducers are generally not used under laboratory conditions, it is necessary to assess how operating environments can affect the transducer performance. NBS subjects pressure transducers to tests of several kinds to determine the effects of temperature, mechanical disturbance, variations in electrical excitation, and aging in use and in storage. The tests are described briefly below.

**Temperature tests:** The transducer is mounted in a temperature-controlled chamber and a static calibration is performed at the laboratory ambient temperature. Then the chamber is set for another temperature in the range of interest (typically between  $-54^{\circ}\text{C}$  and  $177^{\circ}\text{C}$ ) and another static calibration is performed after temperature stability is attained. The procedure is repeated for 15-deg C temperature shifts over the range being investigated. Changes in transducer sensitivity and zero-pressure output can be determined from the data obtained. A final calibration at the starting temperature determines if the transducer has been permanently changed by the temperature cycle.

The effect of temperature transients also has been studied at NBS. The zero-pressure output of flush-mounted

pressure transducers is monitored as the transducer face is lowered into contact with a pool of molten metal.<sup>5</sup> Some of the transducer types tested did not depart from the manufacturers' specifications, but the zero-pressure indication of others shifted radically, returning within specified tolerance only as the thermal front engulfed the entire transducer and uniform transducer temperature is reestablished. Transducers expected to be subjected in use to thermal transients, as in the case of cryogenic and space applications, should be tested for the effects of such transients.

**Mechanical tests:** To assess the effects of external mechanical disturbances on pressure transducers, the devices are vibrated on an electromagnetic shaker or are subjected to steady acceleration forces on a centrifuge. Output variations due to these mechanical stimuli indicate degradation of the measurement capability of the transducer when operating in such conditions.

**Electrical tests:** Some transducer performance characteristics, such as sensitivity, zero output, and linearity, may be affected by changes in the excitation level. Therefore, the transducers are calibrated statically at various excitation levels.

**Durability tests:** Since pressure transducers are often required to perform satisfactorily over long periods of time, a test procedure was developed which simulates this situation.<sup>6</sup> Pressure stimuli with amplitudes near the full range of the transducer are applied periodically, at a rate of about one per second, until a million cycles have been reached. Static calibrations before, during, and after this "life cycling" procedure permit any permanent change in performance characteristics to be detected.

Another procedure now under study would subject these transducers to storage for several weeks at high temperature to assess performance deterioration under this condition.

**Additional tests on potentiometric transducers:** While the test procedures described above are equally applicable to strain gage and potentiometric pressure transducers (and, in fact, to practically all types of electromechanical pressure transducers), an additional test is applied to potentiometric transducers. This test is required to determine resolution, contact friction, and noise. It is carried out by slowly pressurizing the transducer and monitoring its output by means of a sensitive recorder or oscilloscope.

<sup>1</sup> Methods for Performance-Testing of Electromechanical Pressure Transducers, P. S. Lederer, NBS Tech. Note 411 (1967), available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 25 cents.

<sup>2</sup> Methods for the Dynamic Calibration of Pressure Transducers, J. L. Schweppe et al., NBS Mono. 67 (1963), available from the Superintendent of Documents for 60 cents.

<sup>3</sup> Step Function Pressure Calibrator, U.S. Patent 3 034 332 issued May 15, 1962, to P. S. Lederer.

<sup>4</sup> A liquid medium step-function pressure calibrator, R. O. Smith, J. Basic Engr., Trans. ASME 86, Series D, 723-728 (Dec. 1964).

<sup>5</sup> Pressure transducer response affected by thermal gradients, NBS Tech. News Bull. 50, 64-65 (Apr. 1966).

<sup>6</sup> "Life Cycling" Test on Several Strain Gage Pressure Transducers, P. S. Lederer, NBS Tech. Note 434 (Oct. 1967), available from the Superintendent of Documents for 20 cents.

*John Hilten inspects a pressure transducer before testing the transducer's response to a shock wave.*







## IMPROVED REQUEST PROCESSING SYSTEM

On July 1, 1968, the Clearinghouse implemented an automated document request processing system that increases efficiency in handling orders using coupons. This change emphasizes the importance of ordering documents from the Clearinghouse by coupon. There are two ways of ordering by coupon.

**Prepaid Coupons.** The Clearinghouse prepaid coupon is a tabulating card with a face value of the purchase price of a paper copy or microfiche of a document. The prepaid coupon permits the Clearinghouse to exercise accurate control of orders on data processing equipment. The coupon expedites service since it serves as the method of payment, order form, shipping label, and receipt of sale.

Under the improved processing system an order by prepaid coupon should be shipped within one or two days after it is received by the Clearinghouse. Noncoupon orders will require a longer processing time.

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On July 1, 1968, the Defense Documentation Center (DDC) implemented a new Department of Defense policy under which DDC users requesting hard (paper) copy of DoD technical reports are subject to a charge for such service. Full text will continue to be available to all DDC users in microform at no charge. The service charge for providing hard copies of those technical reports available in microfiche form (generally those accessioned by DDC after July 1965) is \$3 in most cases. Requests for paper copies of these reports must contain prepayment and must be sent to:

Clearinghouse for Federal Scientific and  
Technical Information  
U.S. Department of Commerce  
Springfield, Va. 22151

Other DDC services, such as report bibliographies and hard copies of DDC technical reports not available in

microfiche form, will continue to be provided at no charge. Requests for such services should be sent, on the appropriate DDC form, to Defense Documentation Center.

The Clearinghouse coupons described above may be used to remit the DDC user service charge.

Although DDC users will not have to register with the Clearinghouse they will be requested to include their DDC user code, DoD contract number, and routing information on all orders. The Clearinghouse coupon contains appropriate spaces for this information.

## CAST

CAST, Clearinghouse Announcements in Science and Technology, is a new announcement service available from the Clearinghouse. CAST is designed for quick review of current scientific and technical reports. It provides a simple method for scientists, engineers, and businessmen to scan the flow of new technical information in any of 46 separate fields of technology resulting from research in defense, space, nuclear energy, transportation, area development, education, environment, and other national programs. Of the more than 1000 scientists and engineers who tested CAST, over 85 percent reported that CAST opened up new information sources and saved them valuable time.

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Clearinghouse (410.61)  
U.S. Department of Commerce  
Springfield, Va. 22151

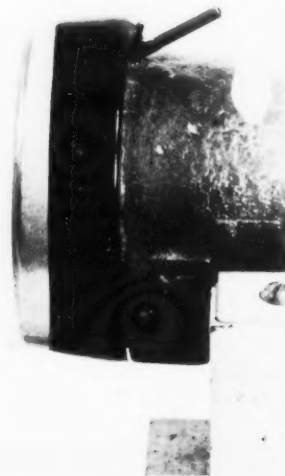
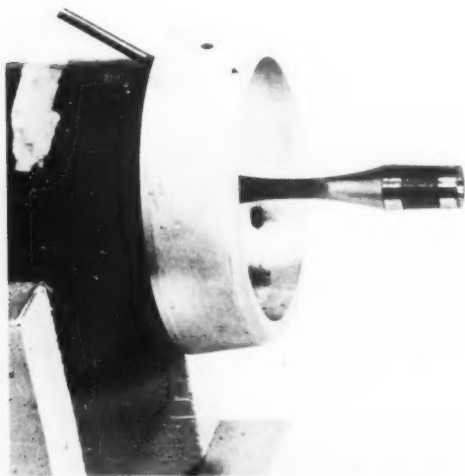


# NBS Studies ATMOSPHERIC CORROSION FATIGUE

## Data Obtained For Titanium And Steel Alloys



*Right: Before starting a fatigue test of a metal specimen, T. R. Shives makes final adjustments to the fatigue machine. Below: Separated bearing boxes of the rotating beam machine expose the specimen and a plastic sleeve. When joined, the plastic sleeve surrounds the specimen forming the environmental chamber into which the desired atmosphere is pumped through tubes on top the bearing boxes.*

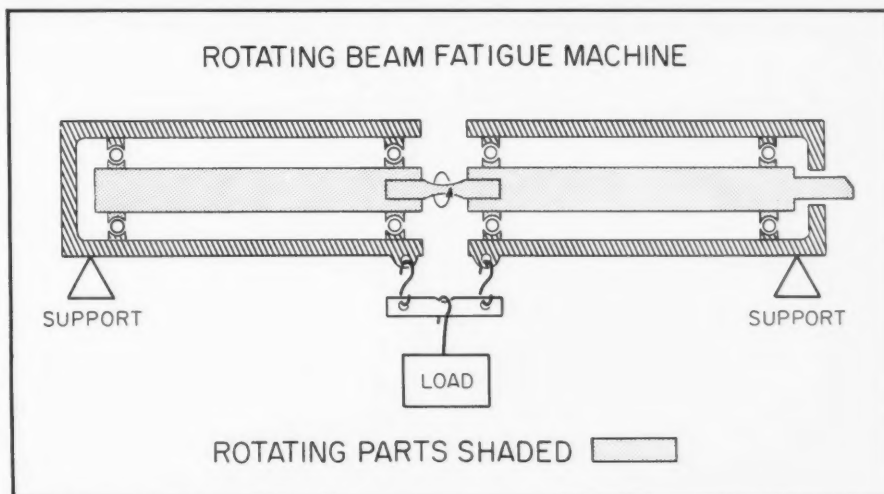


■ For over thirty years it has been realized that the fatigue strengths of many structural metals are lower in a normal atmosphere than they are in vacuum. Known as atmospheric corrosion fatigue, this phenomenon has become the object of renewed interest because of the problems it presents the aircraft industry. A general lack of information exists as to how specific atmospheric constituents affect the fatigue process in metals. For this reason the National Bureau of Standards has investigated the influence of oxygen and water vapor on a number of metals. The most recent data were obtained on a high strength steel and a titanium alloy.<sup>1</sup>

This investigation was conducted by T. R. Shives and J. A. Bennett of the NBS Institute for Materials Research and was sponsored, in part, by the National Aeronautics and Space Administration. The results show that the effects of oxygen and water vapor

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*This schematic illustrates the cycling and stressing features of the rotating beam machine, which applies a uniform bending moment to the specimen. As the specimen is rotated, each point on the specimen surface is subjected to a constant stress amplitude, provided by a suspended load.*



on the titanium alloy are small but significant, while on the steel, the presence of water vapor causes a marked reduction in fatigue strength.

These alloys belong to two common classes of structural metals and were known from previous investigations to be affected by corrosion fatigue. The steel is an AISI 4340, high-strength, nickel-chromium-molybdenum steel commonly used in aircraft and widely employed in all sectors of industry. The Ti-4Al-4Mn alloy is also used in the aircraft industry, primarily because of its resistance to oxidation at high temperatures. This property makes it useful in airframe forgings, aircraft fasteners, and particularly in forged aircraft gas-turbine compressor blades, disks, and rings.

The fatigue strengths of the alloys were tested at room temperature in four atmospheres—dry helium, moist helium, dry air, and moist air. These atmospheres represent, respectively, an inert atmosphere and water vapor and oxygen atmospheres, independently and together. The fatigue strength is defined as the maximum stress that the alloy can sustain before fracturing for a given number of cycles of stress. Tests were conducted on a rotating beam machine, equipped with

an environmental chamber, which applies a uniform bending moment with a constant stress amplitude. Specimens were cycled at speeds of about 9000 rpm while being stressed at amplitudes ranging from 641 to 807 MN/m<sup>2</sup> (93 to 117 ksi; 1 ksi = 1000 psi) for the titanium alloy and 855 to 1241 MN/m<sup>2</sup> (124 to 180 ksi) for the steel. Prior to testing, the steel had been heat treated to a tensile strength of approximately 2060 MN/m<sup>2</sup> (300 ksi).

Results showed the fatigue strengths of both alloys to be highest in dry helium. For both materials the lowest strength was in the moist helium, but the magnitude of the effect was much greater in the steel than in the titanium alloy. The relative fatigue strengths of the two materials in the four environments can be seen from the following table, in which the fatigue strength in the dry inert atmosphere is taken as 100.

Relative Fatigue Strengths

	Dry helium	Dry air	Moist air	Moist helium
AISI 4340 steel--	100	97	86	80
Ti-4Al-4Mn ----	100	99	97	96

Many of the steel specimens, although vacuum melted and relatively

free of impurities, failed from fatigue cracks which originated below the surface at inclusions. It was found that there existed an inverse correlation between the fatigue performance of the individual specimens and the size of the inclusions. These data point up the importance of reducing the size of inclusions in steel if high fatigue strengths are to be obtained.

The results of the environmental experiments, particularly on the high-strength steel, emphasize the important role that surface chemical reactions can play in the phenomenon of fatigue failure. Although the mechanism by which these reactions affect the initiation and propagation of fatigue cracks is not well understood, this investigation contributes toward the necessary experimental information that will be required to form the basis for a satisfactory theory of the phenomenon. From a practical point of view, the results indicate the magnitude of the improvement in fatigue performance that can be expected if the surface of the metal is protected from the atmosphere.

<sup>1</sup> Shives, T. R., and Bennett, J. A., The Effect of environment on the fatigue properties of selected engineering alloys, J. Mater. ASTM (to be published).

# CONFERENCE & PUBLICATION *Briefs*

## CERAMICS SYMPOSIUM HELD AT NBS

The Symposium on Mechanical and Thermal Properties of Ceramics, which took place at the NBS laboratories in Gaithersburg, Md., April 1-2, 1968, brought together over 200 scientists and engineers. Jointly sponsored by the American Ceramic Society (ACM), the American Society for Testing and Materials (ASTM), and the National Bureau of Standards, the conference concentrated on the property-character relationship—the dependence of ceramic properties upon microstructure and composition. General Chairman for the conference was J. B. Wachtman, Jr., of NBS.

Ceramists often make use of the thermal and mechanical properties of a ceramic in the design of a part. In many cases these properties influence the design of the device in which the part is to be used. The Symposium therefore was intended to provide a basis for understanding the property-character relationship as well as criteria for proper selection and use of ceramic materials.

The conference opened with a survey of the activities of ACM and ASTM, two of the principal institutions through which American ceramists communicate and formulate standards. The presidents of ACM and ASTM, J. S. Owens and F. J. Mardulier, respectively, summarized their organizations' activities in ceramics; J. C. Richmond of NBS also spoke on ASTM's work in this field.

Dr. Owens explained that an understanding of the property-character relationship and the process of character development during processing are needed as a guide in producing new ceramics. Standard test methods for both character determination and property measurement are therefore important aids in developing this understanding. In this regard, the process by which U.S. standards are developed, and the role of ACM and ASTM in developing such standards, was described.

Merely understanding the property-character relationship and having standard test methods will not ensure the commercial development of new ceramics. This development will occur only if justified by demand. In view of this fact, C. S. Bersch (Bureau of Naval Weapons) discussed new markets open to ceramics; he also emphasized the requirement for reliability with the consequent need for good testing procedures.

The discussion of thermal properties of ceramics began with a paper on the melting points of these refractory materials by S. J. Schneider (NBS). One of the factors

limiting the use of ceramics at high temperature is the development of stress accompanying thermal gradients. Thermal shock parameters involving elastic moduli and thermal expansion have been used as a rough guide to the "thermal shock resistance" of materials, but it has long been recognized that a complete analysis of the heat flow and temperature distribution for each particular device is needed. The properties needed for such analysis were covered by R. K. Kirby ("Thermal Expansion"), D. R. Flynn ("Thermal Conductivity"), and J. C. Richmond ("Thermal Radiation"), all of NBS.

On the second day of the symposium, the mechanical properties, which determine response to stress, whether of thermal or mechanical origin, were discussed. These included presentations on elastic deformation by J. B. Wachtman, Jr. (NBS), inelastic deformation by R. M. Spriggs (Lehigh Univ.), inelastic deformation of non-oxide ceramics by G. E. Hollox (RIAS), and viscoelasticity of glass by P. B. de Macedo (Catholic Univ. of America).

Fracture of polycrystalline ceramics resulting from stress usually occurs suddenly and completely. Therefore, it is necessary not only to understand the characteristics of brittle fracture, but also to design for the use of ceramics with this in mind. S. M. Wiederhorn (NBS) approached the subject from two points of view: fracture mechanics as a branch of continuum mechanics, and effects of defects and environment. Finally, the subject of mechanical testing was treated in a separate paper by L. Mordfin and M. J. Kerper (Office of Aerospace Research).

The Proceedings of this Symposium will be published by NBS and should be available by January 1969.

## ELECTRONIC COMPOSITION IN PRINTING

A Symposium on Electronic Composition in Printing, held at NBS June 15 and 16, 1967, reviewed the state-of-the-art in this rapidly advancing field of computer application. The importance of this field is exemplified by its great potential for increased efficiency and savings in the Federal Government. Edited by Richard W. Lee and Roy W. Worral, NBS Spec. Publ. 295, *Electronic Composition in Printing—Proceedings of a Symposium*<sup>1</sup> (128 pages, 70 cents) is the report of that conference.

Twenty-nine papers were presented and are published in the Proceedings. They include a diverse group by leaders from industry reporting recent technological advances in the field, such as computer image drawing from

digital data. The texts of the talks of J. L. Harrison, the Public Printer, and J. F. Haley, a representative of the Congressional Joint Committee on Printing, on Government policy are also recorded. Another series of papers is devoted to nongovernment applications and research; and a final group details specific applications within several Government agencies.

### ORGANIC COATINGS

During the last twenty years, many significant technological advances have been made in the field of organic coatings. Selecting from the array of continually emerging materials requires both a knowledge of what is available and an understanding of where and how these materials and techniques can best be utilized. *Organic Coatings—Properties, Selection, and Use*,<sup>1</sup> Bldg. Sci. Series-7 (\$2.50), by Aaron G. Roberts, was prepared to fill the need for a comprehensive treatise in this field.

Besides presenting practical information on the properties, selection, and use of organic coatings, the 187-page publication provides basic principles in a number of important areas such as polymer structure, coatings formulation, pigment function, use of thinners, coating system compatibility, and theory of corrosion. Each chapter deals with a major area of the coatings field, including types of coatings, properties of synthetic resins, selection of coating systems, storage and safety, application methods, and surface preparation and pretreatment. Specific references to Federal specifications are given in the form of a classified table and a series of summarizing charts. Finally, a selected bibliography and a comprehensive index are provided.

Written primarily to inform the engineer, architect, maintenance superintendent, and procurement officer, this volume is sufficiently broad in scope to serve as a general manual, a concise text, or a convenient reference source.

### WEATHERABILITY OF PLASTICS

The increasing use of plastics for outdoor purposes has required the development of tests that measure the ability of plastic to withstand weathering. A Symposium on the Weatherability of Plastic Materials was held February 8-9, 1967, at the NBS facilities in Gaithersburg, Md., and jointly sponsored by the Manufacturing Chemists' Association and the Bureau. It provided a forum to review and highlight significant activities in the evaluation of plastic weatherability, as well as an opportunity to introduce new developments and approaches toward predicting the outdoor durability of these materials.

*Weatherability of Plastic Materials*<sup>2</sup> (Applied Polymers Symposia No. 4) is the proceedings of that Symposium and is edited by Musa R. Kamal. The volume presents 19 technical papers divided into four categories: (1) measurement of the chemical and physical changes occurring in plastics; (2) measurement of the radiant energy flux present in natural or artificial weathering

tests; (3) mathematical analysis of weathering data; and (4) natural and laboratory weathering tests of specific plastic formulations.

The publication of these Symposium papers in one volume represents a beginning in the utilization of available information and a contribution in defining some of the major unsolved problems in the weatherability of plastics.

### SCHEDULED NBS-SPONSORED CONFERENCES

*Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or cosponsored by NBS and are open to all interested persons unless specifically noted. If no address is indicated, the conference will be held at NBS, Gaithersburg, Md., and inquiries should be sent in care of Special Activities Section, Rm. A600, Administration Bldg., National Bureau of Standards, Washington, D.C. 20234.*

**1968 International Conference on Modern Trends in Activation Analysis.** Oct. 7-11. Cosponsors: U.S. AEC; International Atomic Energy Agency; EURISOTOP. Contact: P. D. LaFleur (NBS Analytical Chemistry Division).

**Conference on the Structural Properties of Hydroxyapatite and Related Compounds.** Sept. 11-13. Contact: W. E. Brown (NBS Polymers Division).

**Measurements Technology.** Sept. 17-18. Cosponsor: Scientific Apparatus Makers Association. Contact: G. E. Lawrence (SAMA).

**Conference on Thermal Expansion.** Sept. 18-20. Cosponsor: Westinghouse Astronuclear Laboratory. Contact: R. K. Kirby (NBS Metrology Division).

**Performance of Buildings—Concept and Measurement.** Sept. 23-25. Contact: W. W. Walton (NBS Building Research Division).

**1968 Standards Laboratory Conference.** Aug. 26-29. Sponsor: National Conference of Standards Laboratories (NCSL). Contact: George Goulette, University of Colorado, Boulder, Colo. 80302.

**Standards for High Pressure Research.** Oct. 14-18. Contact: C. W. Beckett (NBS Heat Division).

**American Cybernetics Association.** Oct. 24-25. Contact: Carl Hammer (UNIVAC).

**Seminar on Durability of Insulating Glass.** Nov. 14-15. Cosponsor: ASTM Committee E-6 on Methods of Testing and Building Construction. Contact: Henry Robinson (NBS Building Research Division).

**Workshop on Mass Spectrometry.** Nov. 18-19. Contact: A. J. Ahearn (NBS Analytical Chemistry Division).

<sup>1</sup> Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

<sup>2</sup> Published as part of the *Journal of Applied Polymer Science*. Single copies available from Interscience Publishers, 1 Wiley Dr., Somerset, N.J. 08873, for \$7.95.





# STANDARDS AND CALIBRATION

## CALIBRATION SERVICE FOR MICROWAVE POWER IN WR28 WAVEGUIDE (26.5–40.0 GHz)

A calibration service for the measurement of effective efficiency of bolometer units in WR28 waveguide has been announced by the Radio Standards Laboratory (Boulder, Colo.) of the NBS Institute for Basic Standards. A service for the measurement of calibration factor of bolometer units and bolometer-coupler units will be available at a later time. Calibrations are performed at any frequency in the useful range of the waveguide (26.5–40.0 GHz). However, for most purposes, it is sufficient that the calibration be made at one or more of the suggested frequencies of 29.0, 33.0, and 37.0 GHz.

Bolometer units calibrated by NBS are used as interlaboratory standards and form the principal link to the NBS reference standards of microwave power. The calibrated bolometer units are then used to calibrate other power measuring devices in various standards laboratories. They also can serve as a check on the operation of power measuring systems.

The *effective efficiency of bolometer units*<sup>1</sup> is defined as the ratio of the substituted d-c power in the bolometer unit to the microwave power dissipated within the bolometer unit.

In calibrating the NBS working standards of the relatively small WR28 waveguide, use was made of a new design of the microwave microcalorimeters<sup>2</sup> that have been used so successfully by the Radio Standards Laboratory for a number of years in calibrating bolometer units of larger waveguide sizes. The twin-joule geometry was modified so that the portions absorbing microwave energy have relatively small mass and volume. In addition, the development of a new temperature controller<sup>3</sup> and water bath<sup>4</sup> permits operation of the microcalorimeter at an operating temperature which is constant to within  $\pm 25$  millionths of a degree Celsius for a 24-hr period. The attainment of this temperature stability increases the accuracy with which the bolometer units can be calibrated.

In making the transfer measurement from an NBS working standard to a bolometer unit submitted for calibration as an interlaboratory standard, use is made of a reflectometer<sup>5</sup> in WR28 waveguide.

The effective efficiency of bolometer units in WR28 waveguide can be measured within limits of uncertainty of  $\pm 0.8$  percent provided that the units are of high quality. Flange faces are of particular concern and must be clean and flat in order to achieve the stated uncertainty.

The element of the bolometer unit submitted for calibration may be of the barretter or thermistor type and of

either 100- or 200-ohms resistance, operating at a bias current between 3.5 and 15 mA. The bolometer units should be of either the fixed-tuned or untuned broadband type. Measurements are made over a power range of 0.1 to 10 mW. The bolometer units can be fitted with either square or round flanges.

## CALIBRATION SERVICES FOR REFLECTORS AND NONREFLECTING PORTS IN WR42 WAVEGUIDE (18.0–26.5 GHz)

Calibration services for the measurement of reflection coefficient magnitude of waveguide reflectors (mismatches) and nonreflecting ports (including "matched loads") in WR42 waveguide have been announced by the Radio Standards Laboratory (Boulder, Colo.) of the NBS Institute for Basic Standards. Similar services in six larger waveguide sizes (WR 62, 90, 112, 137, 187, and 284) also are available.

Waveguide reflectors are useful as reference standards for the calibration of impedance measuring equipment such as slotted lines and reflectometers.

The term nonreflecting as used here indicates that the waveguide port has been designed or adjusted with the intent to provide a reflection coefficient magnitude,  $|\Gamma|$ , equal to zero. Although most waveguide ports for such applications cannot produce a reflection coefficient magnitude identically equal to zero, their reflection coefficient magnitudes often approach zero very closely. Useful information is gained by evaluating the extent to which this is accomplished. There are many applications in the laboratory for nonreflecting waveguide ports, including the termination commonly referred to as a "matched load."

Calibrations can be performed at any frequency within the range of the waveguide (18.0–26.5 GHz). However, for most purposes, it is sufficient that the calibration be made at one or more of the suggested frequencies of 19.8, 22.0, and 23.8 GHz.

Measurement of the reflection coefficient magnitude of waveguide reflectors can be made over the range from 0.024 to 0.2 with estimated limits of uncertainty of:

- (a)  $\pm (0.0004 + 0.0017 |\Gamma|)$  for the round flange-type connector,
- (b)  $\pm (0.0008 + 0.0017 |\Gamma|)$  for the square flange-type connector, where  $|\Gamma|$  is the numerical value of the measured magnitude.

Reflection coefficient magnitude measurements of nonreflecting waveguide ports with values less than 0.024 can be made with estimated limits of uncertainty of:

- (a)  $\pm (0.0004 + 0.0032 |\Gamma|)$  for the round flange-type connector,



(b)  $\pm (0.0008 + 0.0032 |\Gamma|)$  for the square flange-type connector, where  $|\Gamma|$  is the numerical value of the measured magnitude.

The present reflection calibration system can be used to measure reflection coefficient magnitudes as small as 0.0001 with the above uncertainties.

Reflections may be introduced in a measurement system by misalignment of the port or by foreign matter and mechanical imperfections at the flange junction. The uncertainties of calibration stated above will be exceeded if precautions are not taken.

Considerable care must be exercised in the use of waveguide reflectors, and particularly nonreflecting waveguide ports, by keeping the mating connector flange surfaces smooth and clean beyond that of usual practice. Accurate alignment of the interior surfaces of the joining waveguides at the flange junction also is very important when using these components of small waveguide size (WR42). The back of the flange which makes contact with the connecting bolts should be nominally flat and free of soft materials including paint.<sup>6</sup>

#### NBS INCREASES PHOTODETECTOR CALIBRATION SERVICE

Photodetectors are being used increasingly in such sophisticated equipment as satellite guidance systems and spaceship navigational apparatus, creating, in turn, a need for increased photodetector calibration services. To meet this need, the NBS Institute for Basic Standards recently expanded its calibration service for the measurement of spectral response of photodetectors.

Calibrations can now be performed at NBS over the visible and near-infrared wavelength regions (0.35 to 1.8  $\mu\text{m}$ ) with a resolution of approximately 3.5 nanometers in the visible region and 7.0 nm in the near infrared. The relative-spectral response of the photodetector can be measured for unmodulated light (dc), or for modulated light (ac). The ac relative-spectral response can be measured from 1 Hz to 1 kHz at 10 fixed frequencies. In addition, the absolute spectral response per unit wavelength band and unit irradiance can be measured for photodetectors at certain fixed wavelengths. The uncertainty in the relative-spectral response measurements is within approximately  $\pm 3$  percent of the peak response, varying somewhat with wavelength and detector type. The absolute spectral response measurements are estimated to be uncertain within  $\pm 5$  percent, again depending on wavelength and detector type.

Since calibrated photodetectors may change their absolute and relative-spectral response with temperature, time, and electrical parameters, great care should be exercised in the use of a calibrated detector and its response should be checked frequently for changes in performance.

A complete listing of NBS photodetector calibration services is contained in NBS Special Publication 250, *Calibration and Test Services of the National Bureau of*

*Standards*.<sup>7</sup> Additional information pertaining to photodetector calibration may be obtained from:

David Goebel  
A321 Metrology Bldg.  
National Bureau of Standards  
Washington, D.C. 20234.

#### NEW EDITION OF "NBS CALIBRATION AND TEST SERVICES"

A new edition of *Calibration and Test Services of the National Bureau of Standards* will be ready for distribution in June 1968. The publication is included as No. 250 in the NBS series of *Special Publications* and will be referred to, for short, as SP 250, 1968 Edition. The new edition replaces the 1965 edition of NBS Miscellaneous Publication 250, of the same title, which had been known as MP 250.

Descriptions of NBS calibration and test services which hitherto became official upon publication in the *Federal Register* are now made public via SP 250. General statements about the services will appear in the *Federal Register*, but details on specific services will be given only in SP 250, and will be indicated in the *Federal Register* through "incorporation by reference."<sup>8</sup>

An effort was made, in preparing the new edition, to provide more information and to present it in a more convenient form. Sections of the text devoted to a particular physical quantity or type of instrument include statements of the available ranges, convenient test points, estimated uncertainties, and limiting parameters. Also included are definitions of units and concepts, explanatory notes, lists of references, and precautions concerning subsequent use of the device calibrated.

Descriptions of specific services in SP 250 are headed by a statement giving the office location and phone number of the technical section of the Bureau which carries the responsibility for that field. The first three digits of the item number of a service correspond to the individual NBS laboratory which provides the service.

The new edition was prepared on an electric typewriter linked by phone to a remote time-shared computer which performs typographic justification and permits changes or insertions to be made in the computer printout without the need for complete retyping and subsequent proof-reading. It is hoped eventually to link the computer in turn to photocomposition equipment.

The text is stored on magnetic tape subject to quick recall and modification, so that notification of changes can be sent to users of NBS services more promptly than had been possible with the older techniques. These changes will be announced by a serially numbered "Measurement User's Bulletin," which it is suggested should be filed in a loose-leaf binder as an appendix to SP 250. The Bulletins will include both informal items of news and formal lists of minor text changes to be made by the user in his copy of SP 250. When necessary, Bulletins will be

continued  
159

## STANDARDS AND CALIBRATIONS *continued*

accompanied by complete replacement pages for pages of SP 250 that become out of date.

Copies of SP 250 will be sent to individuals now on the mailing list maintained by the NBS Office of Technical Information and Publications. Additional copies may be purchased for \$1.75 each from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Those who are not now on the mailing list can get on it by returning the post card from the last page of their copy of SP 250; no action is necessary for those now on the list. Measurement User's Bulletins, including replacement pages for SP 250, will be sent at no charge to all individuals on the list.

### NEW USA STANDARD NOMENCLATURE AND SYMBOLS FOR RADIATION, LIGHT, AND COLOR

A new USA Standard, Nomenclature and Definitions for Illuminating Engineering, developed by the IES Nomenclature Committee under the chairmanship of L. E. Barbrow of NBS, is now available in the form of a 49-page booklet.<sup>9</sup> This Standard (Z7.1-1967), besides including terms of particular interest in illuminating engineering, is also of general interest because it contains terms, definitions, and symbols in the fields of photometry and radiometry that are entirely consistent with those adopted by Committees of the International Commission on Illumination, the International Organization for Standardization, the International Electrotechnical Commission, and the SUN Commission of the International Union of Pure and Applied Physics.

This is the first Standard published in this country, and possibly in the world, that contains up-to-date terminology in the fields of photometry and radiometry of such widespread acceptance that it can reasonably be expected to serve for many years as the authentic source for radiometric and photometric terms. It is expected that these definitions and symbols will similarly be approved by technical societies abroad.

This new Standard makes official many important changes in nomenclature that have been introduced in recent years to improve consistency both internally and with other disciplines. Examples are the group of terms *efficacy*, *efficiency*, *visibility*, and *luminosity*, each of which in the past has had some usage that was confused with the usage of one or more other terms. The terms *efficacy* and *efficiency* are now logically differentiated, the former being expressed in units such as lumens per watt while the latter is expressed in dimensionless numbers.

The famous "bell-shaped" curve that serves as the basis for defining the spectral relationship between radiation and light, and which in the past was called the visibility curve or the relative luminosity curve, is now officially termed the *spectral luminous efficiency* curve.

The term *emittance* is deprecated in favor of *exitance*

to denote flux leaving a surface per unit area because the flux need not be "emitted"—it may be transmitted or reflected. The term *distribution temperature* has been introduced to differentiate between a spectral distribution that simulates that of a blackbody as against one (like that of a "white" fluorescent lamp) that differs widely from that of a blackbody of the same *color temperature*. Another new term, *luminance factor*, will be receiving extensive usage concurrently with the growing acceptance of SI, the international system of units, which necessitates the deprecation of luminance units having the dimension "lumens per unit area" (e.g., footlambert).<sup>10</sup>

The new USA Standard Z7.1-1967 supersedes American Standards Z58.1.1-1953, Nomenclature for Radiometry and Photometry, and C42.55-1956, Definitions of Illuminating Engineering Terms, in their entireties. It also supersedes those portions of American Standards Y10.4-1957, Letter Symbols for Heat and Thermodynamics and Z10.6-1948, Letter Symbols for Physics, that deal with symbols for radiometric quantities.

### TENNESSEE RECEIVES NEW WEIGHTS AND MEASURES STANDARDS

On Thursday, May 2, Tennessee received a new set of weights and measures standards under a program to replace the standards of all 50 States. A. V. Astin, NBS Director, presented the set to Tennessee's Governor Buford Ellington in a ceremony at the Ellington Agricultural Center in Nashville.

Many of the States' standards have been in use for 100 years or more. The Bureau is supervising their replacement to increase measurement competence and uniformity throughout the Nation. Previously, new standards were presented to Ohio, Illinois, Oregon, Utah, California, New Mexico, Delaware, and Connecticut. Within the next year sets will be presented to Kentucky, Arkansas, Florida, Georgia, Hawaii, Maine, Missouri, North Carolina, Pennsylvania, West Virginia, and Wisconsin.

New standards and instruments are being provided to about 10 States per year until all State standards facilities are modernized.

### STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz

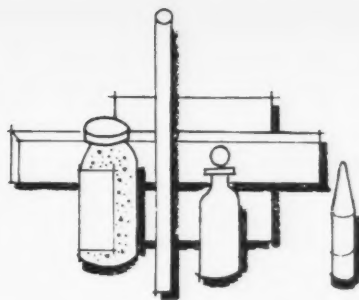
WWVH—2.5, 5.0, 10.0, and 15.0 MHz

WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. The pulses occur at intervals that are longer than one second by 300 parts in  $10^{10}$  due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France.

*continued on page 164*  
NBS Technical News Bulletin

# STANDARD REFERENCE MATERIALS



*Standard Reference Materials are well-characterized materials disseminated by NBS to be used in calibrating and evaluating measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base. These materials are certified for chemical composition or for a particular physical or chemical property. They are used on-site in science and industry for calibrating the instruments and methods used for production and quality control of raw materials, chemicals, metals, ceramics, fuels, and radioactive nuclides in manufacturing processes and in research. This column regularly reports on the issuance of new and renewal Standard Reference Materials and on latest developments in the Standard Reference Materials Program.*

The NBS Office of Standard Reference Materials has recently added six new standards to the more than 600 standard reference materials<sup>1</sup> it disseminates to science and industry for use in calibrating equipment and for controlling product quality. Also, nine radioactivity standards have been recalibrated.

## ZINC CHEMICAL COMPOSITION STANDARDS

Three zinc chemical composition standards have been prepared and certified to meet the needs of analysts and others working at trace level concentrations.

Two of the standards, NBS Nos. 682 and 683, are in the form of semicircular bar segments about  $2\frac{1}{4}$  inches in diameter, 1 inch deep at mid-diameter, and  $\frac{3}{4}$  inch long. The third standard, No. 728, is in the form of shot about  $\frac{1}{8}$  inch in diameter.

The zinc materials were analyzed by spark source mass spectroscopy, neutron activation, and atomic absorption spectroscopy.

Each of the three standards was prepared from the same starting material—a special lot of high-grade electrolytic zinc. This material was further purified by vapor distillation, zone refining, and degasification to obtain the high-purity zinc.

The high-purity zinc, NBS No. 682, is intended as a research material to further both chemical and physical methods of characterization. It is expected to serve for the development of new or improved methods and techniques for extending the sensitivity of detection in determining trace constituents by chemical analysis; optical emission, spark source mass, and x-ray spectroscopy; and by activation and electrical resistivity methods. The price of NBS No. 682 is \$85 per unit.<sup>2</sup>

The purified material for No. 682 is of such high purity that many of the analytical techniques available and used at NBS were unable to detect most impurities that were found in the original starting material. Some elements, however, listed on the certificate of analysis were detected using activation analysis and spark source mass spectrometer techniques. Copper, determined by atomic absorption and spectrophotometric methods, is certified at 0.042 parts per million by weight.

The pure zinc, No. 683, in the same physical form as No. 682, was prepared to provide a homogeneous reference material for the analysis of pure zinc. It is certified for cadmium, copper, iron, lead, and silver. These elements are present in the range of 1 to 10 ppm by weight. This standard can be purchased for \$50 per unit.<sup>2</sup>

Intermediate purity zinc, No. 728, is similar in chemical composition to No. 683, but is in the form of pellets about  $\frac{1}{8}$  inch in diameter. It is furnished in units of about one pound for \$38 per unit.<sup>2</sup>

Cominco American, Inc. supplied the starting material and conducted the purification operations. Homogeneity testing was done at the Bureau's Gaithersburg, Md., site and at its Boulder, Colo., site. The samples tested were selected to represent the extremes in chemical composition to be expected from the preparation procedures.

Analyses of the final material and certification were carried out in the Analytical Chemistry Division of the NBS Institute for Materials Research. Atomic absorption measurements were made by T. C. Rains, spectrophotometry by R. W. Burke and E. R. Deardorff, spark source mass spectrometry (isotopic dilution) by R. Alvarez and P. Paulsen, polarography by E. June Maienthal, and neutron activation by B. A. Thompson and D. A. Becker.

## CAST STEEL STANDARDS

Two solid-form, cast-steel standard reference materials have been prepared and certified for use in calibration of optical emission and x-ray spectrometers employed by steel casting producers and by consumers of steel castings in defense and civilian industries.

The standards, NBS Nos. 1138 and 1139, are certified for carbon, manganese, phosphorus, sulfur, silicon, chromium, nickel, molybdenum, copper, and aluminum. They provide the range of chemical composition and homogeneity necessary for producers and consumers to calibrate their instruments for analyzing compositions specified by the newer ASTM and military specifications for cast steels.

*continued on page 165*



# NEWS

*This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data, located in the Administration Building at the NBS Gaithersburg Laboratories.*

## **NSRDS Coverage of Atomic and Molecular Properties**

One of the major areas of effort in the National Standard Reference Data System is that of atomic and molecular properties. This area encompasses primarily properties characteristic of individual atoms or molecules rather than substances in any specific state of aggregation. Among the major topics defined for high priority attention by projects and data centers in this area are: Fundamental constants and properties, atomic energy levels, atomic spectral data, atomic and molecular x-ray spectral data, atomic and molecular collision data, particle-surface interactions, plasma properties, direct spectral data, information on molecular energy levels derived from spectral data—for both diatomic and polyatomic molecules, other well-defined properties of atoms and molecules, transition probabilities, computed functions, interatomic and intermolecular forces.

Reference data on atomic and molecular properties find application in two broad areas—basic scientific research and the extension of theoretical understanding on one hand, and technological problems, including analysis and identification of substances, on the other.

General guidance for the atomic and molecular properties program is provided by an advisory panel headed by E. U. Condon of the University of Colorado. At the outset, the advisory panel recognized that close attention

would be necessary in several areas, and that subpanels of specialists in the individual topics could appropriately be convened to consider needs.

Three specialized advisory groups have met so far. The first group is a continuing advisory body on infrared spectroscopy—the Board of Management of the Coblenz Society. This group has met several times at the request of the Office of Standard Reference Data to provide advice and guidance of several sorts. One of its specific tasks, to prepare criteria for the evaluation of infrared spectra, has been described in more detail in *NSRDS News* for September 1966.<sup>1</sup> In addition, the Board has given advice on the development of infrared spectral data compilation projects at various quality levels.

The second group is an ad hoc advisory group on NMR spectroscopy, which was organized by B. L. Shapiro and met in November 1967 in Washington, D.C., to discuss data needs and possible compilation projects on chemical aspects of NMR spectroscopy (see *NSRDS News*,<sup>2</sup> May 1968).

The third group, an ad hoc panel on the application of computers to spectral information, was convened on July 24 and 25, 1967, with E. R. Lippincott as Chairman. In addition to recommendations to the Office of Standard Reference Data, this panel provided discussions leading to a U.S. presentation at the 9th European Congress on Molecular Spectroscopy, which was held under the sponsorship of the International Union of Pure and Applied Chemistry in Madrid, September 10–15, 1967.

The advisory panel has developed a list of 57 specific topics in atomic and molecular properties and has given 34 of these high priority rating. Twenty of the 34 are receiving some compilation or planning attention under NSRDS projects (in some cases, a single project covers several items). Projects under other sponsorship are covering five topics. In addition, several of the most important items, such as molecular spectroscopic data, are being considered by two or more projects at the same time. The



Office of Standard Reference Data tries to coordinate such multiple coverage, and to eliminate undesirable duplication of effort.

Most of the projects in the atomic and molecular properties area have already produced useful publications. So far eight compilations of data have been published in the NSRDS series, plus two which appeared in *Reviews of Modern Physics*. Eleven specialized bibliographies have been published, as have one set of criteria for evaluation and two directories of workers in specialized fields. (See the December 1967 and June 1968 issues of *NSRDS News*<sup>3</sup> for listing of the publications.)

### Thermodynamic Properties of Copper, Silver, and Gold

NSRDS-NBS-18, *Critical Analysis of the Heat-Capacity Data of the Literature and Evaluation of Thermodynamic Properties of Copper, Silver, and Gold from 0 to 300 °K*<sup>4</sup> (40 cents), by George T. Furukawa, William G. Saba, and Martin L. Reilly, is the first in a series of critical compilations of low-temperature heat-capacity data.

The objective of this series of publications is to present critically evaluated tables of heat capacity and the derived thermodynamic properties between 0 and 300 K to meet the needs of physical chemists, physicists, and engineers. In the investigation of chemical equilibria and thermodynamic properties, the interest is most often at the higher temperatures (room temperature and above). The effect of small uncertainties in the evaluation of the heat capacities at the lowest temperatures (below about 50 K) is usually less significant to these quantities. Besides their use in precise cryogenic design applications, accurate heat-capacity data at the lowest temperatures are indispensable in studies of lattice dynamics, energy states of magnetic materials, electronic distributions, order-disorder processes, and critical phenomena. Heat capacity is the property through which most experimental observations and theories of physical properties can be correlated and tested. Moreover, heat-capacity measurements can be experimentally realized with high accuracy. The data at the lowest temperatures have, therefore, been evaluated as carefully as the accuracy of the measurements would permit.

In preparing NSRDS-NBS-18, the literature sources of heat-capacity data on copper, silver, and gold between 0 and 300 K were compiled and the data critically analyzed.

Tables of heat capacity ( $C_p$ ), enthalpy ( $H-H_0^\circ$ ), entropy ( $S^\circ$ ), Gibbs energy ( $G-H_0^\circ$ ), enthalpy function ( $\frac{H-H_0^\circ}{T}$ ), and Gibbs energy function ( $\frac{G-H_0^\circ}{T}$ ) were obtained from the

analyses. The literature values of the heat-capacity, the electronic coefficient of heat-capacity ( $\gamma$ ), and the 0 K limiting Debye characteristic temperature ( $\Theta_D(0)$ ) are compared with the selected values. The sources of the data

are tabulated chronologically along with the temperature range of measurements, purity of sample, and the pertinent experimental procedures used. A bibliography of the references and a brief appraisal of low-temperature calorimetry are also included in this publication.

### Second Conference on Neutron Cross Sections and Technology

The Second Conference on Neutron Cross Sections and Technology was held at the Shoreham Hotel in Washington, D.C., March 4-7, 1968. The meeting was sponsored by the Atomic Energy Commission, the National Bureau of Standards, the American Physical Society, and the Reactor Physics and Shielding Divisions of the American Nuclear Society.

The conference provided a common meeting area for the exchange of information among nuclear scientists and engineers interested and working in neutron cross sections.

Since the initial conference two years ago on the same general subject,<sup>5</sup> a great many new or revised experimental data became available and automated data handling procedures and facilities have been introduced. Consequently, a new sub-discipline of nuclear physics entitled data evaluation has emerged, forming a necessary intermediary bridge between the measurers of nuclear data and the users in applied fields. Also, in connection with the design of nuclear reactors, there has evolved a much clearer indication of the real value of basic data and, to some extent, of their practical economic worth. These general subjects were covered during the Conference by 19 invited papers and the 107 contributed papers. Proceedings of the Conference are being published, under the editorship of D. T. Goldman, Conference Program Chairman, and will be available from the Government Printing Office as NBS Special Publication 299.

### Proceedings of the Forum of Federally Supported Information Analysis Centers

The trend in the United States technical community toward the establishment of information analysis centers has accelerated rapidly. Such centers have become a significant factor in improving the accessibility of scientific and technical information.

Several of these centers are associated with NSRDS and are supported to a large degree by the Federal Government. In early 1967, the Committee on Scientific and Technical Information (COSATI) of the Federal Council for Science and Technology established a "Panel on Information Analysis Centers" to examine policy and operational questions relating to such centers and to make recommendations to COSATI and its member agencies.

Following an examination of the many problems associated with the operation and development of information analysis centers, the Panel sponsored a Forum to allow information analysis center representatives to exchange ideas with each other, their sponsors, and other

*continued*  
163



## NSRDS NEWS *continued*

government program officials. The meeting was also intended to inform information analysis center managers of governmental policy developments and legislation of importance to their centers. The Forum was held at the National Bureau of Standards in Gaithersburg, Md., Nov. 7 and 8, 1967.

*The Proceedings of the Forum of Federally Supported Information Analysis Centers, November 7-8, 1967*, 65 pages, PB 177051, is available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, for \$3.

### Second Edition of OMNITAB Published

NBS Handbook 101, *OMNITAB, A Computer Program For Statistical and Numerical Analysis*,<sup>1</sup> 1968 ed. (275 pages, \$3), by Joseph Hilsenrath, Guy G. Ziegler, Carla G. Messina, Philip J. Walsh, and Robert J. Herbold, describes the characteristics, operation, application, and design of a general-purpose digital computer program developed and employed at the National Bureau of Standards for statistical and numerical analysis of experimental data, and for a wide variety of computations in applied mathematics, science, and engineering.

Three important characteristics of the OMNITAB program have influenced the preparation of this work in the present format. First, the generality of the program permits its ready application to such diverse problems as frequency sharing of satellites, reference tables for thermocouples, the influence of range measurements of tropospheric refraction of radio waves, analysis and fitting of molecular spectra, and a variety of problems from biometrics to econometrics to sociology. Secondly, the

interpretive character of the program enables it to respond to simple English language instructions. This feature permits nonprogrammers to use digital computers in a manner highly analogous to the way they use desk calculators. Finally, the conciseness of the instruction set for a wide class of problems makes the system ideal for use with remote computer stations.

NBS Handbook 101 is essentially a user's manual. It discusses the general philosophy and motivation for the program design and gives specific instructions on the application of the program to a variety of calculations arising in research and development establishments. The widespread use of the program at NBS and the interest shown in it by other agencies have motivated the preparation of this volume in the NBS Handbook series.

The second edition of OMNITAB differs from the first in the following ways. Not only have typographical errors been corrected, but also the number of commands has been amplified to clarify ambiguities. A section has been added describing some branching instructions which are present in the program but were not included in the first edition.

An appendix written by David Hogben has been added. The appendix amplifies the discussion of a large number of commands and shows how the existing commands can be used to perform fairly sophisticated analysis of experiments that were not specifically provided for.

<sup>1</sup> NSRDS News, NBS Tech. News Bull. 50, No. 9, 166 (Sept. 1966).

<sup>2</sup> NSRDS News, NBS Tech. News Bull. 52, No. 5, 112 (May 1968).

<sup>3</sup> NSRDS News, NBS Tech. News Bull. 51, No. 12, 274 (Dec. 1967); also, NSRDS News, NBS Tech. News Bull. 52, No. 6, 134 (June 1968).

<sup>4</sup> Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

<sup>5</sup> Goldstein, H., and Goldman, D. T., Two neutron sciences, *Phys. Today* 19, No. 6 (1966).

## STANDARDS AND CALIBRATIONS *continued*

Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment made on August 1, 1968.*

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be an adjustment made on August 1, 1968. The seconds pulses emitted from WWVB will be retarded 200 ms.*

<sup>1</sup> Desch, R. F., and Larson, R. E., Bolometric microwave power calibration techniques at the National Bureau of Standards, *IEEE Trans. Instr. Meas.* IM-12, No. 1, 29-33 (June 1963).

<sup>2</sup> Harvey, M. E., Nonidentical twin microwave calorimeter (to be published).

<sup>3</sup> Larsen, N. T., Fifty microdegree temperature controller, *Rev. Sci. Instr.* 39, 1-12 (Jan. 1968).

<sup>4</sup> Harvey, M. E., Precision temperature-controlled water bath, *Rev. Sci. Instr.* 39, 13-18 (Jan. 1968).

<sup>5</sup> Engen, G. F., A transfer instrument for the intercomparison of microwave power meters, *IRE Trans. Instr.* I-9, No. 2, 202-208 (Sept. 1960).

<sup>6</sup> For further details, see Anson, W. J., A guide to the use of the modified reflectometer technique of VSWR measurement, *J. Res. NBS 65C (Engr. and Instr.)*, 217-223 (Oct.-Dec. 1961).

<sup>7</sup> Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for \$1.75.

<sup>8</sup> Official descriptions of services and standard materials, NBS Tech. News Bull. 52, No. 3, 64 (Mar. 1968).

<sup>9</sup> Copies of the new USA Standard Z7.1-1967 are available from the Illuminating Engineering Society, 145 East 47th St., New York, N.Y. 10017, \$3 per copy.

<sup>10</sup> Barbrow, L. E., The metric system in illuminating engineering, *Illum. Engr.* 62, 638-640 (Nov. 1967).

## REFERENCE MATERIALS *continued*

These will require more strict control of chemical composition than was formerly necessary.

The homogeneity testing and chemical analysis of the cast steel standards were conducted by the Analytical Chemistry Division of the NBS Institute for Materials Research in cooperation with the Steel Founders Society of America.

The standards are sold for \$60 per unit<sup>2</sup> in the form of cast sections 1 1/4 inches square and 1/2 inch thick. A certificate of analysis showing the results of the cooperating laboratories is included with each standard.

### RADIOACTIVITY STANDARDS

A new radioactivity standard, cadmium-109-silver-109m, has been prepared and certified and nine radium-226 solution standards have been recalibrated. This work was carried out under the direction of W. B. Mann, Chief of the Radioactivity Section in the Bureau's new Center for Radiation Research.

#### CADMIUM-109-SILVER-109m STANDARD

Cadmium-109 decays by electron-capture to the isomeric state of silver-109m; following the electron-capture process it emits K-x-rays in the range of 22 to 25 keV and a single gamma ray of 88.006 keV.<sup>3</sup> This decay scheme is useful for energy calibration and relative-efficiency calibration of gamma-ray spectrometers for the scientific disciplines in which these instruments are used as analytical tools.

The standard, NBS No. 4202, consists of cadmium-109, deposited as the chloride, on polyester tape approximately 0.006-cm thick and covered by another layer of the same tape. The gamma-ray emission rate of NBS No. 4202 was

approximately  $1 \times 10^5$   $\gamma$ /s in December 1967. This standard costs \$88 per unit.<sup>2</sup>

### RADIUM-226 SOLUTION STANDARDS

The radium gamma-ray solution standards, NBS Nos. 4955 through 4963 which were originally made up in 1947, have been recalibrated using the more accurate working standards now available. The energy emission rates of the current working standards were determined by measurement with the national radium standards in the NBS radiation balance.

The nominal radium-226 contents of NBS Nos. 4955 and 4956 are 0.1 and 0.2 microgram, respectively. For NBS Nos. 4957 through 4963, the nominal radium-226 contents range from 0.5 microgram for No. 4957 to 50 micrograms for No. 4963.

Random samples were selected from the stocks of Nos. 4955 and 4956, and their gamma-ray emission rates were compared with those of the NBS working standards. For Nos. 4957 to 4963 inclusive, the gamma-ray emission rate of each unit in the stock was compared with those of the NBS working standards.

The recalibrated radium-226 standards cost \$58 per unit and weigh approximately 5 grams each.<sup>2</sup> They are supplied in flame-sealed glass ampoules.

<sup>1</sup> For a complete list of Standard Reference Materials available from NBS, see *Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards*, NBS Misc. Publ. 260 (1968 ed.) for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which update Misc. Publ. 260 are supplied to users on request.

<sup>2</sup> These standards may be purchased for the price indicated from the Office of Standard Reference Materials, Rm. B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

<sup>3</sup> Schima, F. J., and Hutchinson, J. M. R., *Energy of the isomeric transition in <sup>109</sup>Ag*, Nucl. Phys. **A102**, 667-672 (1967).

## PATENTS GRANTED ON NBS INVENTIONS

*The following U.S. Patents have been granted to NBS inventors since the last listing in December 1965. The patents are assigned (or licensed as indicated) to the United States of America, as represented by the Secretary of the Department noted in parentheses:*

3,211,637	Oct. 12, 1965	Homopolymers of 4-Chloroperfluoro-Heptadiene-1,6. Leo A. Wall and James E. Fearn (Navy)
3,218,916	Nov. 23, 1965	Wave Front Shearing Interferometer. James B. Saunders (Commerce)
3,224,818	Dec. 21, 1965	Combined Electromagnetic and Electromechanical Power Converter. Herbert Sixsmith (Commerce)

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165

July 1968

# **PATENTS** *continued*

- |           |                |   |
|-----------|----------------|---|
| 3,226,610 | Dec. 28, 1965  | Constant-Current Semiconductor Device.<br>George G. Harman, Jr., Theodore Higier, Owen L. Meyer, and Richard L. Raybold (Commerce)                                    |
| 3,230,478 | Jan. 18, 1966  | Universal Stroboscopic Electron Schlieren Detector Having Beam-Pulse Synchronizing Means.<br>Stanley R. Mielczarek, David C. Schubert, and Ladislaus L. Marton (Navy) |
| 3,236,752 | Feb. 22, 1966  | Method of Alloying Phosphorus and Nickel in a Fused Salt Bath.<br>Dwight E. Couch (Commerce)  |
| 3,239,758 | Mar. 8, 1966   | System for Measuring Pulse Power Using Sampling and Comparison Techniques.<br>Paul A. Hudson, Warner L. Ecklund, and Arthur R. Ondrejka (Commerce)                    |
| 3,250,177 | May 10, 1966   | Image Evaluation Device.<br>Roland V. Shack (Army)  |
| 3,265,746 | Aug. 9, 1966   | Method of Making Perfluorostyrene.<br>Leo A. Wall and Joseph M. Antonucci (Navy)  |
| 3,270,189 | Aug. 30, 1966  | Device for Determining an Angle from a Set of Orthogonal Components.<br>Herbert D. Cook (Commerce)  |
| 3,273,160 | Sept. 13, 1966 | Indenting Recorder with Illumination Means.<br>Gustave Shapiro and Robert O. Stone (Commerce)   |
| 3,276,062 | Oct. 4, 1966   | Modulated Subcarrier System for Measuring Attenuation and Phase Shift.<br>Francis J. Palumbo (Commerce)   |
| 3,282,187 | Nov. 1, 1966   | Fast-Operating, Large-Aperture Shutter.<br>Esther C. Cassidy and Donald H. Tsai (Commerce)  |
| 3,295,118 | Dec. 27, 1966  | Read-Out Circuit for Flux-Gate Reproducer Heads.<br>Robert F. Brown, Jr. (Commerce)   |
| 3,296,110 | Jan. 3, 1967   | Process for Making Polyoxymethylene.<br>Robert A. Ruehrwein (Army)  |
| 3,298,221 | Jan. 17, 1967  | Densitometer.<br>Charles E. Miller and Robert B. Jacobs (NASA)  |
| 3,299,009 | Jan. 17, 1967  | Chemically Crimped Nylon Fibers.<br>Stephen D. Bruck (Commerce)   |
| 3,300,066 | Jan. 24, 1967  | Sorting Machine Providing Self-Optimizing Inventory Reduction.<br>Seymour Henig and Ervin C. Palasky (Commerce)   |
| 3,305,674 | Feb. 21, 1967  | Device for Determining an Angle from a Set of Orthogonal Components.<br>Herbert D. Cook (Commerce)  |
| 3,306,740 | Feb. 28, 1967  | High-Temperature Corrosion-Resistant Alloys.<br>LeRoy Wyman and John J. Park (Navy)   |
| 3,311,740 | Mar. 28, 1967  | Switching Apparatus for Controlling the Input Circuit of an Analog Integrator.<br>Walter D. Urban (Navy)  |
| 3,312,106 | Apr. 4, 1967   | Flow Meter.<br>Merlin Davis (Army)  |
| 3,312,949 | Apr. 4, 1967   | Stack-Forming Synchronizer for a Sorting Machine.<br>Seymour Henig (Commerce)   |
| 3,318,797 | May 9, 1967    | Method of Oxidizing Asphalt Flux with Oxides of Nitrogen.<br>Paul G. Campbell and James R. Wright (Commerce)  |
| 3,327,239 | June 20, 1967  | Four-Terminal Direct-Current Amplifier.<br>Robert J. Carpenter (Commerce)   |

# PUBLICATIONS of the National Bureau of Standards\*

## PERIODICALS

*Technical News Bulletin*, Volume 52, No. 6, June 1968, 15 cents.  
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## CURRENT ISSUES OF THE JOURNAL OF RESEARCH

*J. Res. NBS 72A (Phys. and Chem.)*, No. 4 (July-Aug. 1968), \$1.

Mass spectrometric study of photoionization. X. Hydrogen chloride and methyl halides. M. Krauss, J. A. Walker, and V. H. Dibeler.

The fourth and fifth spectra of vanadium (V IV and V V). L. Iglesias.

Variation of absorbance-curve shape with changes in pigment concentration. G. L. Howett.

Periodic acid, a novel oxidant of polycyclic aromatic hydrocarbons. A. J. Fatiadi.

A galvanic cell with a low emf-temperature coefficient. G. N. Roberts and W. J. Hamer.

Synthesis of cerite. J. Ito.

Tables of collision integrals for the  $(m,6)$  potential function for 10 values of  $m$ . M. Klein and F. Smith.

Spectrum of relaxation times in  $\text{GeO}_2$  glass. A. Napolitano and P. B. Macedo.

Resumé of values of the Faraday. W. J. Hamer.

*J. Res. NBS 72B (Math. Sci.)*, No. 2 (Apr.-June 1968), 75 cents.

The probability of an equilibrium point. K. Goldberg, A. J. Goldman, and M. Newman.

Differentiable generalized inverses. J. Z. Heaton and J. W. Evans. On spaces and maps of generalized inverses. J. Z. Heaton and J. W. Evans.

Principal submatrices V: Some results concerning principal submatrices of arbitrary matrices. R. C. Thompson.

Mathematical basis for the plasma kinetic equations (BBGKY). J. J. Sopka.

On the diffusion of an ion sheet in Poiseuille flow. S. Jarvis, Jr. A class of thickness-minimal graphs. A. M. Hobbs and J. W. Grossman.

## OTHER NBS PUBLICATIONS

[Note: The NBS Miscellaneous Publication Series has recently been redesignated the NBS Special Publication Series. Because this is merely a title change and not a new series, the numbering sequence will be retained.]

Blaine, R. L., Arni, H., and DeFore, M. R., Interrelations between cement and concrete properties. Part 3, Compressive strengths of portland cement test mortars and steam-cured mortars, Bldg. Sci. Series 8 (Apr. 1968), 55 cents.

Corliss, C. H., and Tech, J. L., Oscillator strengths and transition probabilities for 3288 lines of Fe I, Mono. 108 (Mar. 1968), 45 cents.

Furukawa, G. T., Saba, W. G., and Reilly, M. L., Critical analysis of the heat-capacity data of the literature and evaluation of thermodynamic properties of copper, silver, and gold from 0 to 300 °K, Natl. Std. Ref. Data Series 18 (Apr. 1968), 40 cents.

Lee, R. W., and Worrall, R. W., Eds., Electronic composition in printing. Proceedings of a Symposium, held at the National Bureau of Standards June 15-16, 1967, Spec. Publ. 295 (Feb. 1968), 70 cents.

Robbins, D., Ed., Disclosures on: Autoeditor—A semi-automatic copy-editing apparatus, Tech. Note 440 (Apr. 1968), 40 cents.

## PUBLICATIONS IN OTHER JOURNALS

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

## CHEMISTRY

Ausloos, P., and Lias, S. G., Gas-phase photolysis of hydrocarbons in the photoionization region, *Rad. Res. Rev.* **1**, No. 1, 75-107 (Mar. 1967).

Ausloos, P., and Lias, S. G., Gas-phase radiolysis of hydrocarbons, *Book, Actions Chimique et Biologiques des Radiations*, Ed. M. Haissinsky, **10**, 1 (Masson and Company, Paris, France, 1967).

Ausloos, P., and Lias, S. G., Photoionization of cycloalkanes in the gas phase. A study of charge transfer-processes, *Book, The Chemistry of Ionization and Excitation*, Ed. G. Johnson and G. Schales, pp. 77-89 (Taylor and Francis, Ltd., London, England 1967).

Ausloos, P., Scala, A. A., and Lias, S. G., Ion-molecule reactions in the condensed-phase radiolysis of hydrocarbon mixtures. II. Cyclopentane and cyclohexane, *J. Am. Chem. Soc.* **89**, 3677-3683 (1967).

Bates, R. G., and Covington, A. K., Behavior of the glass electrode and other pH-responsive electrodes in biological media, *Ann. N.Y. Acad. Sci.* **148**, 67-80 (Feb. 1968).

Currie, L. A., Limits for qualitative detection and quantitative determination, application to radiochemistry, *Anal. Chem.* **40**, No. 3, 586-593 (Mar. 1968).

Fatiadi, A. J., Stable radicals obtained by treatment of azulene with periodic acid and other oxidants, *Chem. Commun.* **8**, 456-458 (Apr. 1968).

Haller, W., Correlation between chromatographic and diffusional behaviour of substances in beds of pore controlled glass. Contribution to the mechanism of steric chromatography, *J. Chromatog.* **32**, 676-684 (1968).

Hetzler, H. B., Robinson, R. A., and Bates, R. G., Conventional  $p_{\text{H}}$  values for buffer solutions of piperazine phosphate from 0° to 50° C, *Anal. Chem.* **40**, 634-636 (Mar. 1968).

Ito, J., A new yttrium magnesium silicate garnet,  $\text{Y}_2\text{Mg}_2\text{Si}_2\text{O}_{12}$  and its rare earth and nickel analogues, *Mater. Res. Bull.* **2**, 1093-1098 (1967).

Lafferty, W. J., Direct  $l$ -type doubling transitions in some axially symmetric molecules, *J. Mol. Spectry.* **25**, No. 8, 359-364 (Mar. 1968).

Marantz, S., and Armstrong, G. T., Heats of combustion of *trans*-stilbene and *trans*-2,2',4,4',6,6'-hexanitrostilbene (HNS), *J. Chem. Eng. Data* **13**, No. 1, 118-121 (Jan. 1968).

May, L., and Spijkerman, J. J., Mössbauer spectroscopy, *Chemistry* **40**, 14-17 (Dec. 1967).

Rasberry, S. D., Caul, H. J., and Yezer, A., X-ray fluorescence analysis of silver dental alloys with correction for a line interference, *Spectrochim. Acta* **23B**, 345-351 (Mar. 1968).

Scala, A. A., and Ausloos, P., Condensed-phase photolysis and radiolysis of 2-methylbutane, *J. Chem. Phys.* **47**, No. 12, 5129-5139 (Dec. 1967).

continued  
167

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**PUBLICATIONS** *continued*

Spijkerman, J. J., The Mössbauer chemical shift in tin chemistry, *Advan. Chem. Ser.* **68**, 105-112 (1968).

**ENGINEERING AND INSTRUMENTATION**

Astin, A. V., A time for action in international standardization, *Mater. Res. Std.* **8**, No. 5, 18-24 (May 1968).

Blandford, J. M., A progress report on the NBS-ARF apparel materials evaluation project, 1st Ann. Conf. Apparel Research Foundation, Nov. 29-Dec. 1, 1967, Washington, D.C. (Apparel Research Foundation, Washington, D.C. 20036, 1967).

Eberhard, J. P., Systems and design—an extrapolation to 2000 A.D., *Mater. Res. Std.* **8**, No. 5, 12-17 (May 1968).

Marzetta, L. A., Incorrect usage of exact closed-loop voltage gain formula in operational amplifiers, *Analog Dialogue Letter* **2**, No. 1, 6 (Mar. 1968).

**MATHEMATICS**

Schofer, R. E., and Levin, B. M., The urban transportation planning process, *Socio-Econ. Plan. Sci.* **1**, 185-197 (Pergamon Press Ltd., London, England, 1967).

**METROLOGY**

Bowman, R. R., Remarks on the paper "Field strength above 1 GHz: Measurement procedures for standard antennas," *Proc. IEEE* **56**, No. 2, 216 (Feb. 1968).

Jespersen, J. L., Kamas, G., and Morgan, A. H., A proposed ranging system with application to VLF timing, *IEEE Trans. Instr. Meas.* **IM-16**, No. 4, 282-285 (Dec. 1967).

**PHYSICS**

Damburg, R. J., and Geltman, S., Excitation of n-2 states in hydrogen by electron impact, *Phys. Rev. Letters* **20**, No. 10, 485-487 (Mar. 1968).

Hanley, H. J. M., and Childs, G. E., Discrepancies between viscosity data for simple gases, *Science* **159**, No. 3819, 1114-1117 (Mar. 1968).

LeVier, R. E., and Branscomb, L. M., Ion chemistry governing mesospheric electron concentrations, *J. Geophys. Res., Space Physics* **73**, No. 1, 27-41 (Jan. 1968).

Manson, S. T., and Cooper, J. W., Photo-ionization in the soft x-ray range: Z dependence in a central-potential model, *Phys. Rev.* **165**, No. 1, 126-138 (Jan. 1968).

Marshak, H., Langsford, A., Wong, C. Y., and Tamura, T., Total neutron cross section of oriented  $^{199}\text{Au}$  from 2 to 135 MeV, *Phys. Rev. Letters* **20**, No. 11, 554-558 (Mar. 1968).

Maximon, L. C., and Tzara, C., Influence of the radiative background on muon and electron scattering from nuclei, *Phys. Letters* **26B**, No. 4, 201-203 (Jan. 1968).

Moore, C. E., Necrology: Carl C. Kiess, *J. Opt. Soc. Am.* **58**, No. 2, 292-293 (Feb. 1968).

O'Connell, J. S., and Prats, F., Photodisintegration of the trinucleon system in a separable potential model, *Phys. Letters* **26B**, No. 4, 197-200 (Jan. 1968).

Pfeiffer, E. R., and Schooley, J. F., Effect of stress on the superconductive transition temperature of strontium titanate, *Phys. Rev. Letters* **19**, No. 14, 783-785 (Oct. 1967).

Schima, F. J., and Hutchinson, J. M. R., Energy of the isomeric transition in  $^{109}\text{Ag}$ , *Nucl. Phys.* **A102**, 667-672 (1967).

Simpson, J. A., Special sources of monoenergetic electrons, *Book, Methods of Experimental Physics, Volume 4, Atomic and Electron Physics, Chapter, Sources of Atomic Particles, Section 1.1.7*, pp. 124-135 (Academic Press Inc., New York, N.Y., 1967).

Swanson, N., Characteristic energy-loss spectra and  $-\text{Im}(1/\epsilon)$  for amorphous and polycrystalline  $\text{Al}_2\text{O}_3$ , *Phys. Rev.* **165**, No. 3, 1067-1070 (Jan. 1968).

Swartzendruber, L. J., and Bennett, L. H., The effect of Fe on the corrosion rate of copper rich Cu-Ni alloys, *Scripta Met.* **2**, 93-98 (1968).

Vriens, L., Simpson, J. A., and Mielczarek, S. R., Tests of Born approximations: Differential and total  $2^1\text{S}$ ,  $2^3\text{P}$ , and  $2^1\text{S}$  cross sections for excitation of He by 100- to 400-eV electrons, *Phys. Rev.* **165**, No. 1, 7-15 (Jan. 1968).

Weiss, A. W., Theoretical electron affinities for some of the alkali and alkaline-earth elements, *Phys. Rev.* **166**, No. 1, 70-74 (Feb. 1968).

Weiss, A. W., Theoretical multiplet strengths for Mg I, Al II, and Si III, *J. Chem. Phys.* **47**, No. 9, 3573-3578 (Nov. 1967).

Wells, J. S., Matarrese, L. M., and Sukle, D. J., Electron spin resonance in single crystals of anhydrous copper sulfate, *J. Chem. Phys.* **47**, No. 7, 2259-2262 (Oct. 1967).

Yakowitz, H., and Heinrich, K. F. J., Quantitative electron probe microanalysis: Absorption correction uncertainty, *Mikrochim. Acta* **1**, 182-200 (1968).

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